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Original Articles

THE DIAGNOSIS AND INTERCEPTION OF CLASS II, DIVISION 2 MALOCCLUSION

Gordon C. Swann, D.D.S., M.Sc., Calgary, Alberta, Canada

INTRODUCTION

Among the common clinical conditions seen by the practicing orthodontist is the malocclusion known and recognized as Class II, Division 2. Clinically, it presents a characteristic picture. However, the literature reveals innumerable descriptions, most of them prompted by an overt attempt to justify, or at least respect, the fact that Angle[1] included this deformity as a division of Class II malocclusion. In preparing the present article an attempt was made to review the literature to glean some facts from the confusion that exists.

From these findings a working hypothesis of the etiology and developmental morphology of Class II, Division 2 malocclusion was developed.

It then was decided to test the validity of this hypothesis in three ways:

1. By means of analysis of series cephalograms of untreated cases.
2. By assessment of treatment results in successfully treated cases.
3. By determining whether these cases can be intercepted at the time this hypothesis suggests.

Review of the Literature.—Since Angle's historic classification, many investigators have carried out cephalometric studies of the morphology of Class II malocclusion and, generally speaking, have included this deformity (Division 2) in their study for what seemed to be more a matter of duty than reason. However, occasionally a distinction has been made between Class II, Division 1 and Division 2 malocclusions and, in so doing, a few authors have made the observa-

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tion that the latter group shows peculiarities which separate it morphologically from the former. In most cases these have been casual observations and have been passed over lightly, usually because the sample of Class II, Division 2 cases was small and the resulting findings were not statistically significant. Hellman[9] did an anthropometric study on dried skulls of Class II malocclusions and showed that in Class II, Division 1 the body of the mandible assumed a more posterior position in relation to the maxilla than in normal skulls, while Class II, Division 2 was a reversal of this condition, that is, the maxillary alveolar process appeared to have drifted anteriorly; the teeth therein consequently were in mesial relation to those of the mandible. Baldridge[2] pointed out that the base bone of the mandible in Class II, Division 2 is in correct anteroposterior relation to the face and cranium, while the mandible is in a posterior position in the first division of Class II. Renfroe,[13] using angular measurements to study facial patterns, observed that the maxilla, as indicated by the position of the anterior nasal spine, is definitely farther forward in Class I and Class II, Division 2 than in Class II, Division 1, while the chin point of both Class I and Class II, Division 2 is farther forward than in Class II, Division 1. Yet, his conclusion, strangely, was that all of Class II is characterized by a posterior position of the mandible as claimed by Angle.

Ricketts,[14] by means of cephalometric laminagraphy, demonstrated that in Class II, Division 1 the condyles and the path of closure showed significantly more distal movement from rest position of the mandible to occlusion than Division 2 cases, while the latter group showed a deeper overbite and the freeway space was greater.

The findings just mentioned illustrate the apparently conflicting evidence that exists.

If the skeletal pattern of Class II, Division 2 is more like that of Class I than of Class II, Division 1, as these workers have shown, to what, then, can one attribute the Class II molar relationship that is seen in the typical case of Class II, Division 2 malocclusion? Brodie[4] stated that the maxillary first permanent molar never was intended to be taken as a fixed, immovable point from which treatment could be started on the assumption that it was correct wherever found. He pointed out that it would move forward out of its correct position if the "integrity of the arch was broken by extraction or *any* cause." He said that "according to Angle's concept, classification is based upon the relation of the lower jaw to cranial anatomy. A Class II case," says Brodie "is one where the lower arch is distal to the upper to the extent of more than half a cusp. If there has been mutilation of the upper arch and the molar has drifted forward until its distobuccal cusp engages the buccal groove of the lower first permanent molar, we are not dealing with a Class II but a Class I case."

Strang,[15] speaking of Class II, Division 2, said that correct treatment calls for complete elevation of the molars and premolars, with distal tipping whereby the mesial sections of the molars are raised toward their normal positions.

This would seem to indicate that he believes these teeth have moved forward of their normal relation to the maxilla. Elsasser and Wylie[8] showed statistically that in Class II, Division 2 males the maxillary first permanent molar is farther forward on the body of the maxilla than in Class I males.

Howes[10] suggested that, normally, anteroposterior growth continues until it is time for the third molars to erupt. "However this growth may be insufficient or lag behind tooth eruption producing either a forward positioning of the buccal teeth or impactions of the second or third molars."

These findings show some consistency of thought regarding the mesial positioning of the upper first permanent molar in Class II, Division 2. At least two other singular features of this malocclusion must be mentioned:

1. This malocclusion is not seen in the deciduous dentition.
2. It appears at a specific stage of dental development.

Working Hypothesis.—The next step was to formulate a working hypothesis regarding the morphologic development of Class II, Division 2 malocclusion. In other words, would it be possible to postulate a theory which would explain the origin of Class II, Division 2 malocclusions and which would agree with all the research findings, even though some of these findings seem in contradiction? The next statement, then, is that working hypothesis (Chart 1).

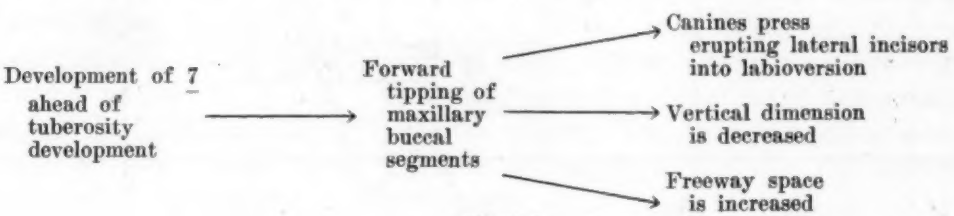

Chart 1.

Shortly after the eruption of the upper permanent lateral incisors, the maxillary first permanent molars move mesially because of the advanced eruptive position of the maxillary second permanent molars. This occurs when the crown development of the maxillary second permanent molars is ahead of tuberosity development. Thus, the unerupted permanent canines are forced to bring pressure on the distolabial surface of the roots of the upper lateral incisors, tipping these teeth into labioversion. This forward tipping of the upper posterior teeth results in loss of vertical dimension, the bite closes, and the freeway space increases. As Broadbent has shown, the lateral incisors normally move into labioversion at this time. However, when the upper buccal segments move mesially to an excessive amount, there is no room for the upper lateral incisors to drop back into alignment, although the pressure that placed them in labioversion is relieved as the canines continue to erupt. As the upper deciduous molars are shed, the leeway space thus is force-closed from the distal and the condition is stabilized. This condition is primarily a problem of aberration of development of the maxilla and eruption of the teeth.

Testing the Hypothesis.—If this sequence of events is true, it should be seen dramatically in serial cephalograms of untreated cases of typical Class II, Division 2 malocclusion begun before this condition developed to a full-blown malocclusion. When the appraisal of the data was first undertaken, it was decided to attempt to answer certain questions in order that as many measurements as possible that had any bearing on the hypothesis might be available. These questions were as follows:

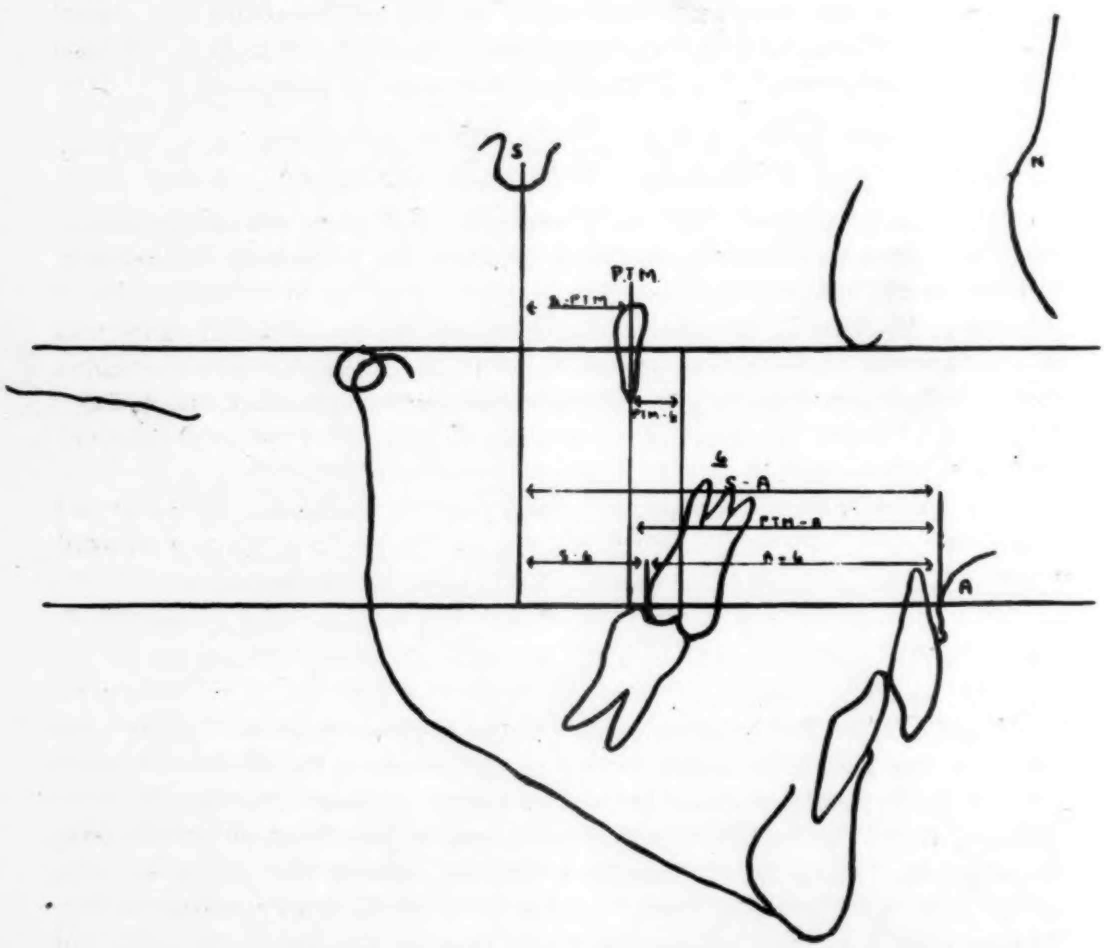

Fig. 1.—Tracing of cephalogram showing anatomic points, as well as lines measured.

1. Is the upper second permanent molar advanced in its eruption in relation to maxillary tuberosity development?

2. Does the upper first permanent molar change position in relation to the cranium and in relation to the maxilla with age?

3. Is there evidence that pressure of the unerupted upper permanent canines on the roots of the permanent lateral incisors tips them into labioversion?

4. If there is a forward shifting of the maxillary buccal segments, does this continue after the loss of the upper deciduous molars?

The material for this phase of the study consisted of serial cephalograms of five untreated cases of Class II, Division 2 malocclusion taken from the files of the Mooseheart Growth Study at the University of Illinois. These cephalograms were traced at various stages of development as the patients progressed from 6 to 16 years.

The various structures were related by means of projections from them perpendicular to the Frankfort plane. In order to minimize the error that might be introduced through projections from points some distance from the Frankfort plane, a second plane (the *A*– plane) was established which passes through point *A*, parallel to the Frankfort plane. The measurement A–$\underline{6}$ as suggested by Baldridge[3] extended from point *A* to a line tangent to the mesial surface of the upper first permanent molar. In this study, however, it was decided to use a tangent to the distal convexity of the upper first permanent molar for measuring the relationships A–$\underline{6}$ and S–$\underline{6}$, since this was more reliably located in lateral cephalograms.

Examination of the cephalograms revealed that the upper second permanent molar was indeed advanced in its eruption and in all cases actually erupted before the lower second permanent molar. This seems significant in the light of Lo's and Moyers'[12] finding that in normal occlusion the lower molars precede the corresponding uppers.

There is evidence that pressure of the unerupted permanent canines on the roots of the lateral incisors caused labial tipping of these teeth during forward shift of the maxillary first permanent molars. The following tables show the changes which took place with regard to the position of the upper first permanent molar at different stages of development.

Table I illustrates these changes occurring over a period of three years prior to the eruption of the upper second permanent molar.

TABLE I

DIMENSION	CHANGES OVER THREE-YEAR PERIOD OF OBSERVATION PRIOR TO ERUPTION OF UPPER SECOND PERMANENT MOLAR
S-PTM	No change in any of the cases.
S-6	This dimension representing the relation between the upper first permanent molar and cranium increased.
PTM-6	The increase was the same as for S-6.
A-6	Decreased. (Since both point A and the upper first permanent molar moved forward in relation to the cranium, this measurement indicates the movement of the upper first permanent molar through the maxilla.)
S-A PTM-A	These two measurements indicate the forward growth at A. The increase here was the same for both measurements, but one-half the distance that the upper first permanent molar moved in relation to these same structures.

Table II shows the changes occurring over a period of four years following the eruption of the upper second permanent molar.

That forward growth of the maxilla, carrying with it the upper first permanent molar, does take place is an accepted fact. However, our findings

TABLE II

DIMENSION	CHANGES OVER FOUR-YEAR PERIOD OF OBSERVATION FOLLOWING ERUPTION OF UPPER SECOND PERMANENT MOLAR
S-PTM	No significant change.
S-6 PTM-6	Increase in these dimensions was the same. However, the forward movement of the upper first permanent molar relative to the cranium was only one-half as much as that which took place prior to the eruption of the upper second permanent molar.
A-6	Following the eruption of the upper second permanent molar there was practically no forward movement of the upper first permanent molar through the maxilla.
S-A PTM-A	Increased only slightly, indicating the slowing down of forward growth of the maxilla in these cases.

suggest that the forward movement of the upper first permanent molar significantly exceeds that of the maxilla, which would lead one to conclude that indeed there is movement of this tooth through the maxilla in patients who have developed Class II, Division 2 malocclusion. Evidence was found to support the idea that most of this forward movement occurred prior to the eruption of the upper second permanent molar. Thus, the study of the serial cephalograms well supports the working hypothesis.

The second method of testing the hypothesis was to select successfully treated cases of Class II, Division 2 malocclusion and assess these treatments in the light of this concept. Cephalograms of twenty-nine cases of Class II, Division 2 malocclusion successfully treated without extraction of permanent teeth were traced before treatment and after retention. Of these, seventeen patients commenced treatment between the ages of 7 and 12 years and were designated as Group A. Twelve patients commenced treatment between the ages of 12 and 25 years and were called Group B. The upper second molar was unerupted in all Group A cases, while in Group B this tooth had erupted into position in the arch.

Landmarks similar to those used for the serial cephalograms were applied in these cases. In addition, angles *SNA* and *SNB* were measured to note any changes in the position of the mandible with treatment. An attempt was made to ascertain any age variations in the response to treatment.

Table III illustrates the changes occurring over the period of treatment in those cases treated prior to eruption of the upper second permanent molar.

TABLE III

DIMENSION	CHANGES OVER PERIOD OF TREATMENT IN PATIENTS TREATED PRIOR TO ERUPTION OF UPPER SECOND PERMANENT MOLAR
S-PTM	No significant change.
S-6 PTM-6	Slight increase, indicating that the upper first permanent molar moved forward in relation to the cranium, but to the same extent as the point *A* moved, that is, apparently less than would take place without treatment.
A-6	No change, indicating that all forward movement of the upper first permanent molar through the maxilla was stopped as a result of treatment.
S-A PTM-A	Increased by an amount similar to that which would occur without any treatment.

Table IV shows the changes occurring as a result of treatment in cases with erupted upper second permanent molars.

TABLE IV

DIMENSION	CHANGES AS RESULT OF TREATMENT IN PATIENTS WITH ERUPTED UPPER SECOND PERMANENT MOLARS
S-PTM	No significant change.
S-6 PTM-6	Decreased during treatment but, since some forward growth of the maxilla was still taking place, this was less than was seen in the next dimension.
A-6	Increase indicated extent of distal movement of the upper first permanent molar through the maxilla with treatment in this age group.
S-A PTM-A	No significant change.

The data on the relation of the pterygomaxillary fissure to the cranium indicate that the posterior border of the maxilla was not affected by treatment in either age group. This agrees with the findings of Brodie, Downs, Goldstein, and Myer.[5]

The effect of treatment was markedly different in the two age groups, however, when our attention was focused on the upper first permanent molar. Analysis of the cephalograms of the patients in the mixed dentition group pointed to the fact that the effect of treatment was to inhibit the forward movement of the upper first permanent molar in relation to the maxilla and to the cranium, while point *A* (representing the anterior of the maxilla) continued its forward growth apparently uninhibited. Downs[7] concluded from his cephalometric appraisal of orthodontic results that growth and development account for a considerable part of the changes which take place with orthodontic treatment. From our findings, there would seem to be a tendency to believe that the reverse is true as far as the upper first permanent molar is concerned.

The figures showing the effect of treatment in the age group between 12 and 25 years suggest that the maxillary first permanent molar was moved distally in relation to the anterior border of the maxilla and it approached the posterior border of the maxilla and cranium. There was no evidence of forward growth of the maxilla during treatment in this age group. Thus, one might conclude that the major part of this forward growth apparently has occurred by the time the upper second molars erupt.

It was noted in all cases that the overbite decreased with the uprighting of the first permanent molars.

Does the position of the mandible change during treatment?

The differences between the angles *SNA* and *SNB* before treatment and the differences after treatment showed that there was no significant change in the relationship of mandible to maxilla in either the mixed or permanent dentition groups. Mandibular functional displacement, then, does not play as important a role in this type of malocclusion as was heretofore believed.

The third method of testing the hypothesis evolved from the results of the first two experiments. In view of these findings and in keeping with the concept in the working hypothesis, it was felt that it might be possible to stop this whole process. To do this, it would be necessary to brace the upper first permanent molar against the eruptive force of the upper second permanent molar.

Ten patients examined in the Department of Orthodontics, University of Toronto, were selected, each demonstrating the upper anterior deformity typical of Class II, Division 2 malocclusion in its incipient stage. Treatment of these patients was begun at what was thought to be the best time to reverse the etiological process.

1. Two lateral cephalograms were taken of each patient at the beginning of treatment, one with the mandible in the position of physiologic rest, the other with the teeth in occlusion. Thompson's analysis of the path of closure was carried out. A linear analysis was made relating the various maxillary structures to one another and to the mandible. The chief purpose of this latter record was to note changes in the relative positions of these structures resulting from treatment procedures.

2. A mixed dentition analysis of each patient was made to determine the relationship between the expected crown width of the permanent canines and premolars in all four segments and the amount of available arch length.

As was pointed out by the Toronto group in their symposium dealing with the timing of treatment in orthodontics,[16] there are three basic types of physiologic aberration: (a) a deformation of the dental arches on a structural basis; (b) a dimensional malrelation between the total mesiodistal width of the teeth and the dental space available for them; and (c) a functional displacement of the mandible when the teeth are in occlusion.

At the same time this concept of the primary etiological tissue site was being developed, Copeland[6] was carrying out an electromyographic study of the changes in resting temporal muscles following myofunctional therapy and Jarvis[11] was studying the role of dental caries in space closure in the mixed dentition. The findings of both men helped develop the concept presented by the Toronto symposium in St. Louis.[16]

A careful analysis of the ten cases of Class II, Division 2 selected for interception showed that they fell into three separate groups strikingly similar to those described in that symposium.

All three conditions met the requirements of Class II, Division 2 malocclusion according to our concept. Each case showed the characteristic picture of the upper anterior region. However, if the first permanent molars were visualized in their proper relationship to the cranium, we then would be dealing with a Class I, and not a Class II, condition.

DIAGNOSIS RELATIVE TO TREATMENT PLANNING

The following case reports illustrate the three variations of Class II, Division 2 malocclusion and their reaction to orthodontic treatment. Basic treatment in all cases was to attempt to move the upper permanent molars distally and to open the bite.

Case 1.—The models and photographs shown in Figs. 2 and 3 portray a typical case of Class II, Division 2 in a boy 7 years of age. The cephalogram shows a normal path of closure from rest to occlusion and the first permanent molars in Class II relationship.

The mixed dentition analysis indicated loss of arch length in the maxilla, due to the forward shift of the first permanent molars, while the integrity of the lower arch has been maintained. Analysis of the models and photographs after treatment conforms with the cephalometric findings that the upper first permanent molars have been held distally in relation to forward growth of the maxilla and the anterior teeth have improved in alignment, while the relationship of the mandible to cranium has not changed.

There has been a noticeable decrease in the degree of overbite.

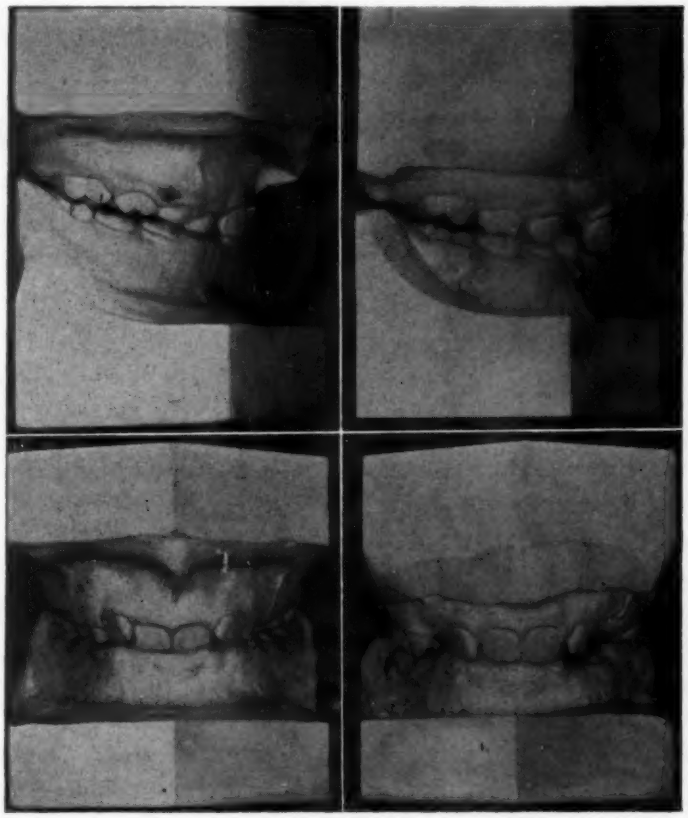

Fig. 2.—Case 1. Plaster models showing changes in molar relationship and overbite following basic treatment.

CASE 2.—Figs. 4 and 5 illustrate the second type, which we have called a bimaxillary Class II, Division 2. The cephalogram taken before treatment shows a normal path of closure of the mandible, while the first permanent molars were in normal mesiodistal relationship. The mixed dentition analysis of this case showed gross lack of leeway in all four buccal segments and supported the Wylie analysis which indicated a deficiency in over-all mandibular and maxillary length.

Analysis of the models, photographs, and cephalograms after fifteen months of treatment similar to that used in Case 1 illustrates its faulty application in this type of case. The upper first permanent molar has continued to move mesially with growth. The anterior relationship and the overbite have not improved, and the relation of mandible to maxilla has remained constant.

CASE 3.—The third type, namely, a functional Class II, Division 2 is shown as Case 3 (Figs. 6 and 7). In the models and photographs, this case appears almost identical with the first type. However, examination of the cephalogram reveals normal relationship of the

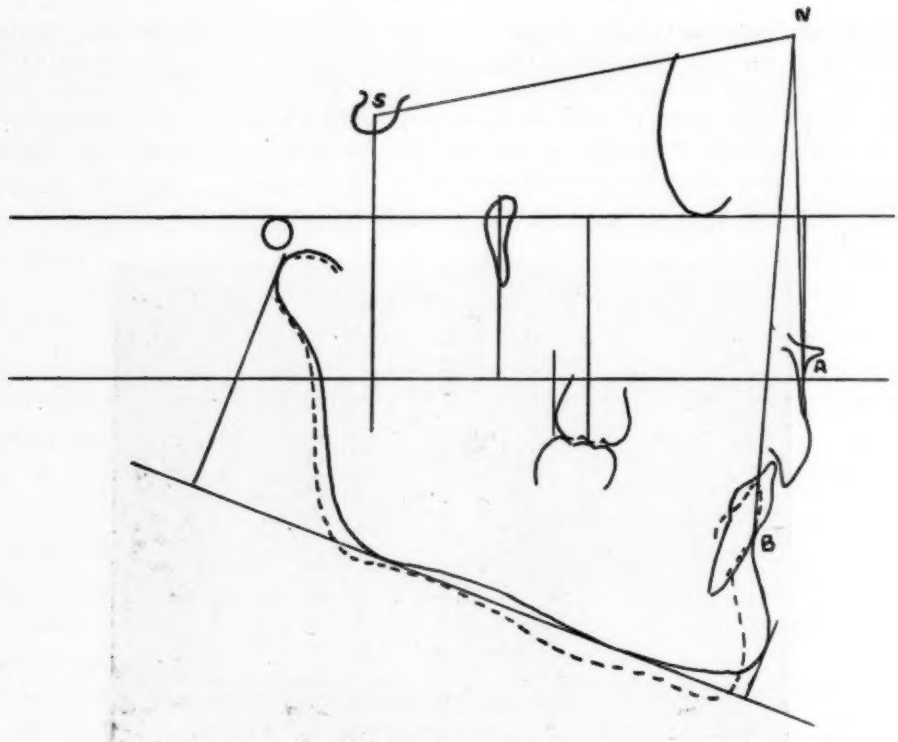

Fig. 3A.—Case 1. Cephalogram taken before treatment.

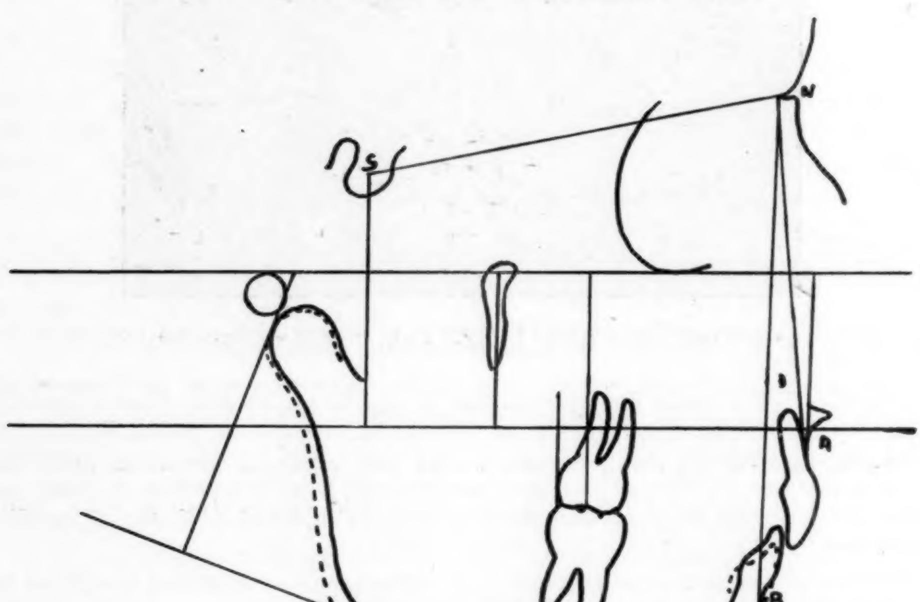

Fig. 3B.—Case 1. Cephalogram taken after treatment.

upper first permanent molar to the cranium. The path of closure of the mandible is definitely distal. The mixed dentition analysis shows adequate leeway in all four buccal segments.

The models, photographs, and cephalograms after twelve months of basic treatment show that the upper first permanent molars have moved forward normally with the forward growth of the maxilla. The mandible now has a normal path of closure, and a Class I molar relationship exists. The degree of over-bite has been decreased appreciably.

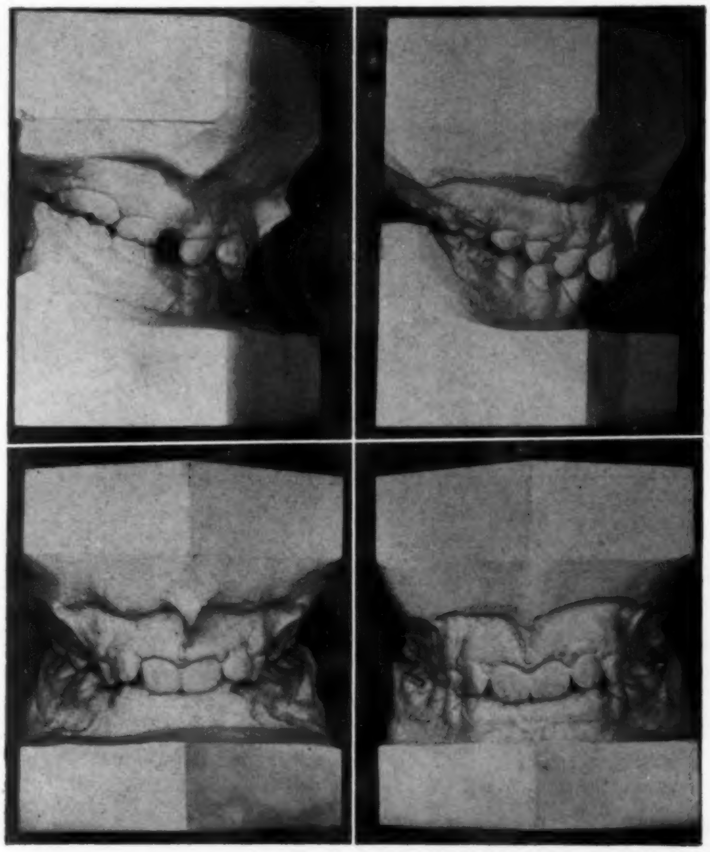

Fig. 4.—Case 2. Plaster models showing no changes in molar relationship and overbite following basic treatment similar to that used in Case 1.

These cases are presented to show only the response to interceptive treatment following the basic concept of our hypothesis with three separate morphologic types of Class II, Division 2 malocclusions.

DISCUSSION

The results of the three experiments discussed in this article make it necessary to qualify the hypothesis.

It is evident that the central theme, or main tendency, in this hypothesis is valid. However, this central theme has other factors superimposed upon it. Thus, even within this one limited group, one is struck by the variations of morphologic characteristics. Tooth size and bone size are variable factors which

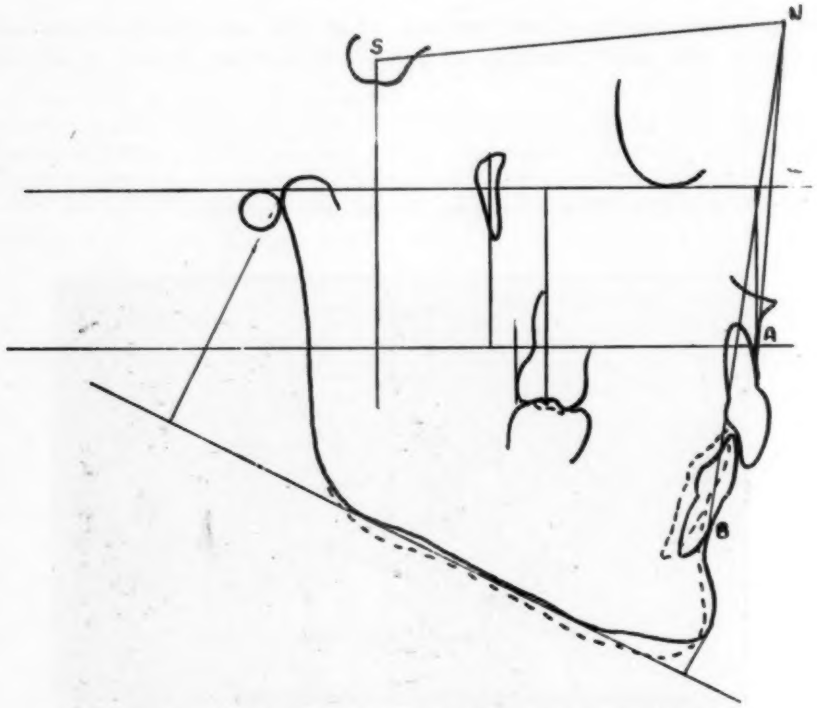

Fig. 5A.—Case 2. Cephalogram taken before treatment.

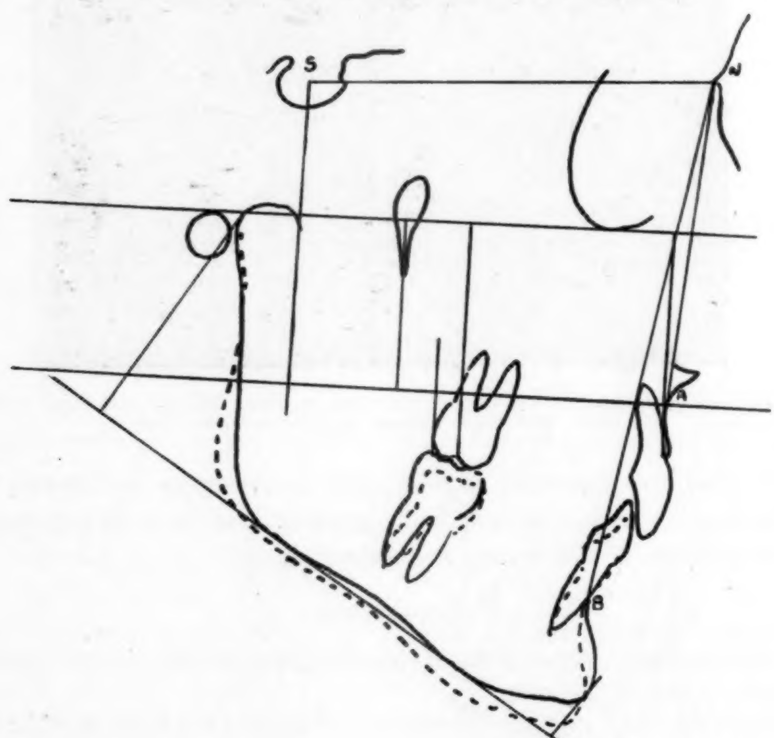

Fig. 5B.—Case 2. Cephalogram taken after treatment.

will occur in Class II, Division 2 cases in a random manner. Functional aspects may or may not occur, according to the amount of mechanical interference in such areas as those of the deciduous canines or the permanent central incisors. In other words, we are dealing with a definite etiological pattern involving the timing of tuberosity growth and the sequence of eruption of certain permanent teeth. Superimposed upon this pattern of tuberosity growth and eruptive sequence are several random factors such as tooth size, bone size, and interference

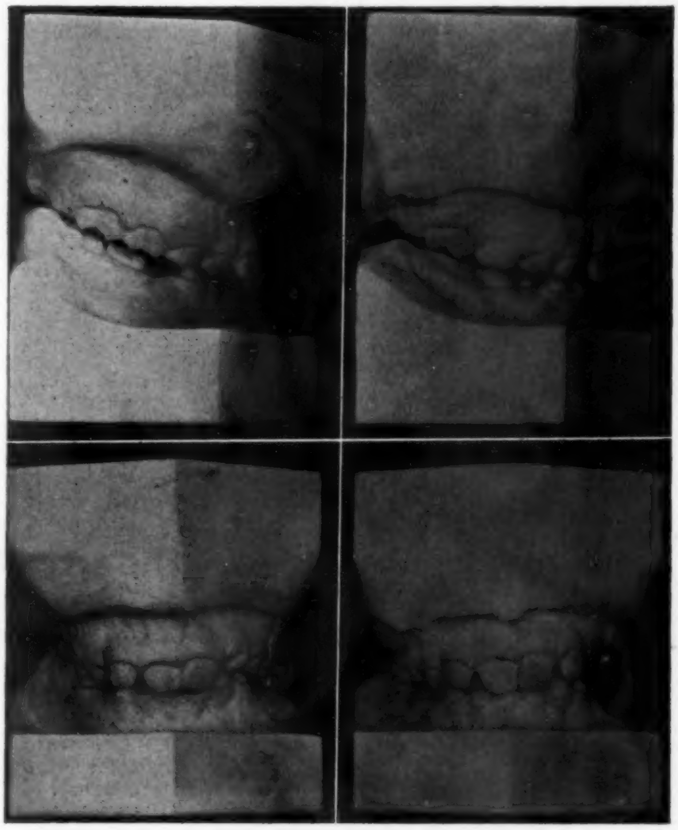

Fig. 6.—Case 3. Plaster models showing change only in mandibular path of closure following basic treatment.

of anterior teeth. These superimposed factors will be distributed in a random manner in Class II, Division 2 cases, just as they are in Class I. In Class II, Division 1, however, we are only too aware of the fact that there is anything but a random distribution of these factors.

Treatment methods must be based on the solid foundation of a thorough diagnosis in the light of this developmental etiology.

CASE 4.—As shown in Fig. 8, this patient has been treated by using sectional edgewise arch wires to move the lateral segments of the maxillary dental arch distally. A Carey sliding twin-wire appliance was used to align the lateral incisors. The upper central incisors were never banded, as they were in a more nearly normal position than any other maxillary teeth. The lips and tongue determined the central incisors' final position, once the pressure

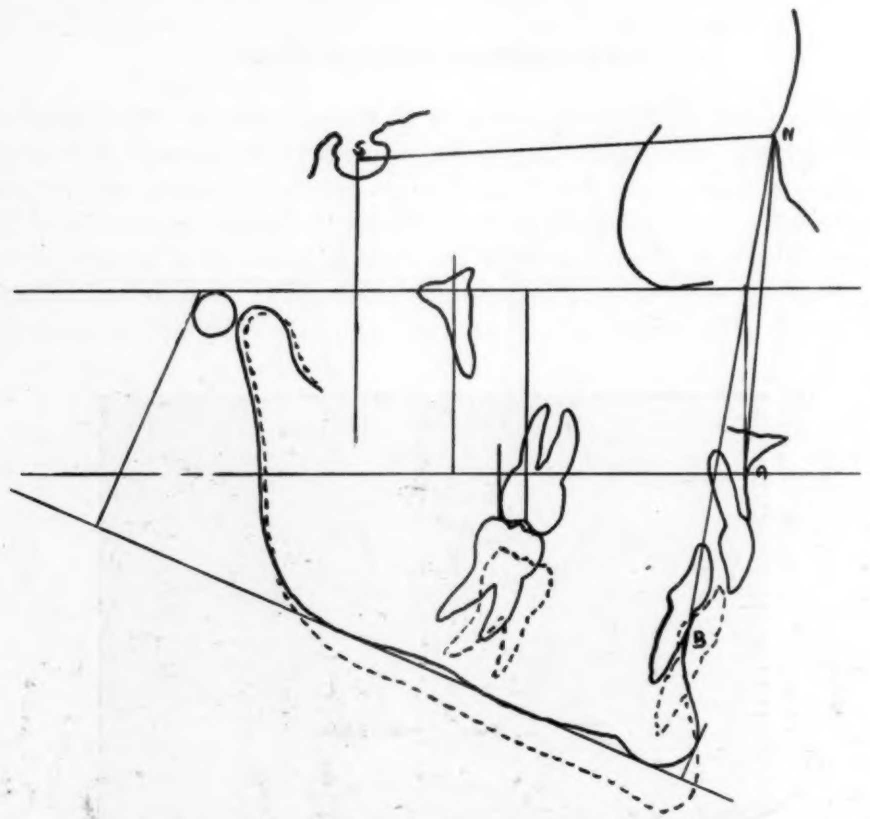

Fig. 7*A*.—Case 3. Cephalogram taken before treatment.

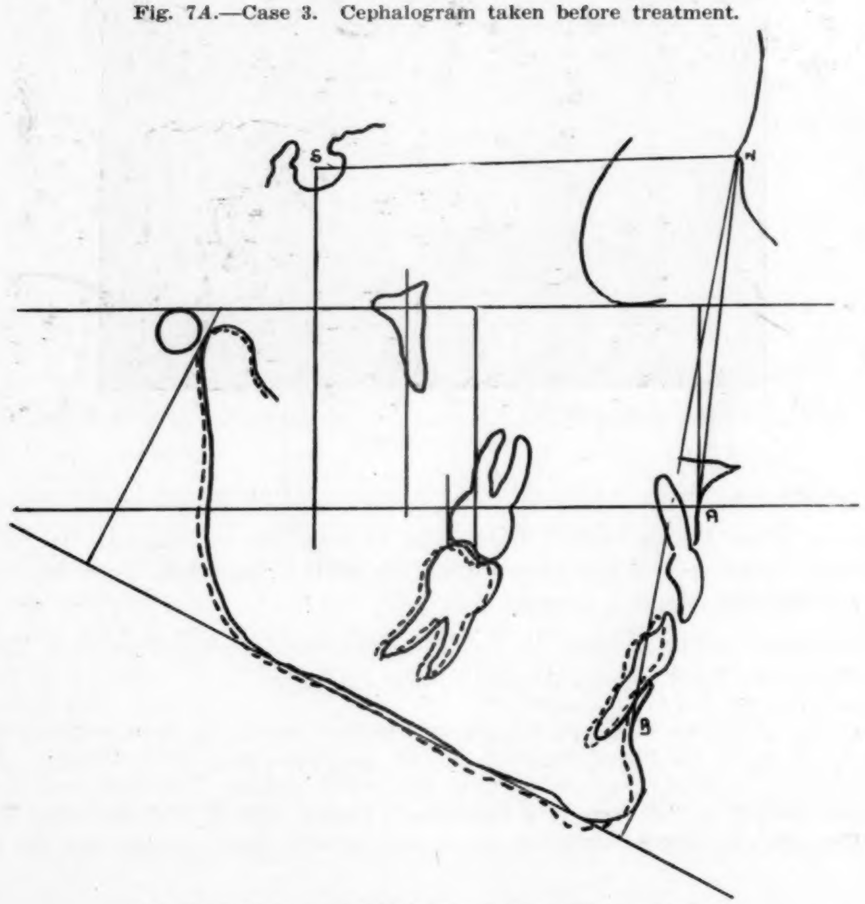

Fig. 7*B*.—Case 3. Cephalogram taken after treatment.

forward against them was released. These results show that the case belongs to the group characterized by shortening of the arch length. The mandible was not functionally retruded, nor did it change its anteroposterior relationship to the cranium with treatment.

To move the upper central incisors labially in *all* cases is to assume that all Class II, Division 2 cases are functional. Our observations have been that only about one-third of them present a functional posterior displacement of the mandible.

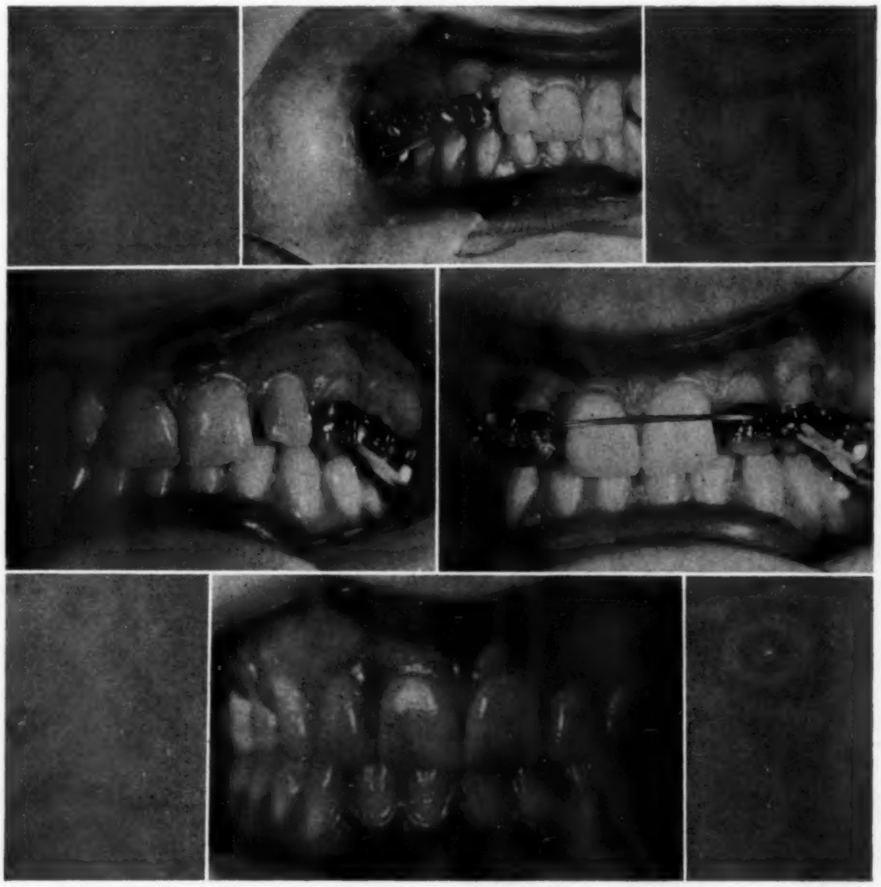

Fig. 8.—Case 4. *A,* Sectional edgewise arch wires used to move lateral segments of the maxillary dental arch distally; *B,* spaces provided for the lateral incisors by moving the upper lateral segments; *C,* the Carey sliding twin-wire appliance used to align the lateral incisors; *D,* anterior view of this case after treatment.

Some functional cases must be treated in part by moving the upper central incisors labially and then repositioning the mandible to its normal anteroposterior relationship to the cranium. In other cases it is necessary to move the upper buccal segments distally. There may be conditions that indicate a combination of these two methods of treatment. When there is a gross malrelationship between the tooth size and the amount of supporting bone, it may be necessary to resort to extractions. However, any treatment, to succeed, must adhere to the basic principle outlined, whether it is begun in the interceptive stages or in the permanent dentition.

Class II, Division 2 malocclusion is a problem of the developmental growth of the maxilla and the eruption of the maxillary teeth. It is not primarily a skeletal dysplasia as is Class II, Division 1.

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713-714 GREYHOUND BLDG.

INTRAORAL FACTORS AFFECTING CASE ASSESSMENT

R. E. Moyers, D.D.S., M.S., Ph.D., E. Harvold, L.D.S., H. Jenkins, D.D.S.
K. Shultis, D.D.S., and J. Thomas Crouch, D.D.S., M.S.
Toronto, Ontario, Canada

INTRODUCTION

FOR several years the interest and attention of students in the field of orthodontics has centered on the morphology of the facial skeleton. This has been due largely to the development of the cephalometric technique. Perhaps more quantitative knowledge is at hand in this area than any other in orthodontics. The clinician, when assesing his problem, must take into account the growth of the facial bones. The deluge of cephalometric studies in recent years has made this abundantly clear. Yet, there are factors, other than the sheer size and shape of these bones, which greatly determine the final tooth position and thus affect clinical assessment and therapy. The purpose of this article is to outline our present knowledge of the intraoral factors affecting the tooth's position. Attention will be directed tc the physiologic rather than the anatomic, to the dynamic rather than the static.

While the final position of the tooth in occlusion is our ultimate concern, a chronological study of the factors that might cause malposition at any time during development seems logical. Four developmental periods are readily observed (Fig. 1): (1) pre-eruptive stage, (2) intra-alveolar eruption, (3) intraoral eruption, and (4) occlusion stage. The physiologic factors affecting the tooth's position vary with each stage; therefore, they will be discussed individually.

PRE-ERUPTIVE STAGE

The original position of the tooth is largely genetically determined by two means: (1) indirectly through the genetic mechanism determining arch development, and (2) directly through the tooth germ itself.

Arch Shape.—The conformation of the arch is, for the most part, a genetically controlled matter. Studies showing racial variation are of interest, for there is a constant distribution, percentagewise, of the different arch forms for various racial groups. All forms appear in every race, but the proportion demonstrating each form varies with the race. For example, there is a great difference in the distribution of arch forms between modern Europeans and the Bantus, a Negroid group. These marked differences in arch shape distribution are difficult to analyze. A comparison of the mean dimensions of the

From the Department of Orthodontics, Faculty of Dentistry, University of Toronto, Toronto, Ontario, Canada.

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arches of English and Bantus shows great similarity $\left(AI = \frac{\text{width}}{\text{length}} \times 100\right)$. Racial variations certainly exist, yet the individual variation within any one race is greater than the variation between races. This holds for arch width, arch length, arch index, and the ratio between arch size and skull size.

The fallacy of using certain of these measurements as a key to tooth position is illustrated by comparing the arch circumference of two arches with

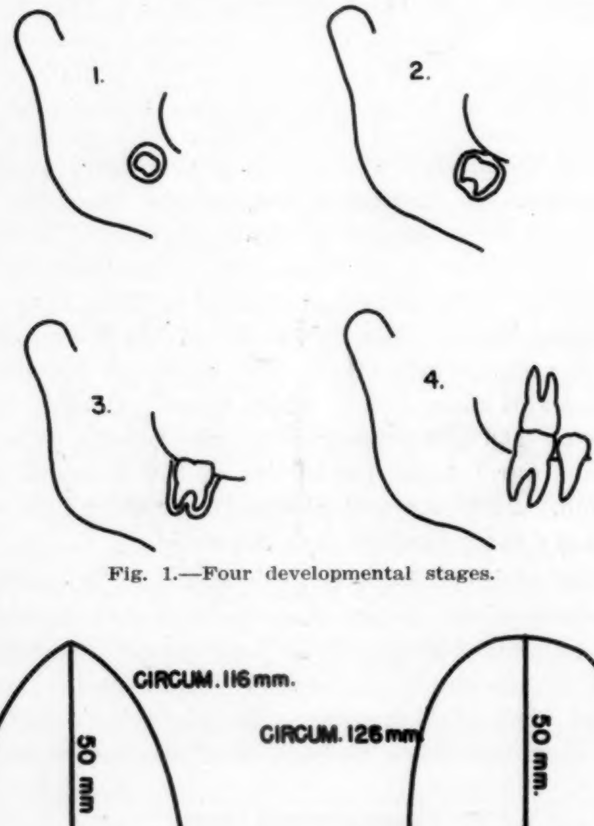

Fig. 1.—Four developmental stages.

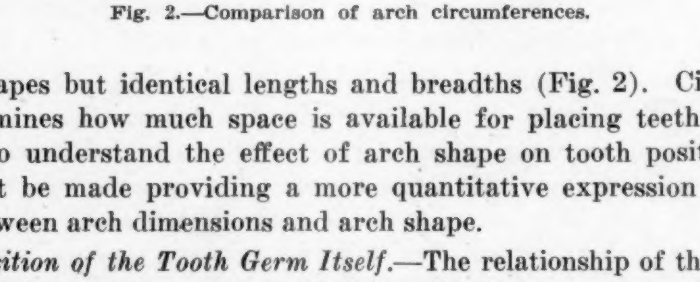

Fig. 2.—Comparison of arch circumferences.

different shapes but identical lengths and breadths (Fig. 2). Circumference alone determines how much space is available for placing teeth in position. If we are to understand the effect of arch shape on tooth position, further studies must be made providing a more quantitative expression of the relationship between arch dimensions and arch shape.

The Position of the Tooth Germ Itself.—The relationship of the tooth germ to the cranial skeleton is as yet unstudied, but a high degree of genetic determination would seem to be expected. Likewise, little is known about any relationships among the various tooth germs. Elaborate and excellent studies on the histodifferentiation and calcification of the dental tissues have been reported.

While there is considerable variation in the timing of these processes because of nutritional and disease disturbances, there is no indication that such disturbances affect the position of the tooth germ.

Tooth size, tooth shape, and the number of teeth to be formed are matters under genetic control. While none of these affect the tooth germ's position originally, all ultimately are of great significance.

We may summarize by saying that in the absence of gross pathology, the position of the tooth germ prior to eruption is largely under the control of genes.

INTRA-ALVEOLAR ERUPTION

Eruption is the process of movement of the tooth from its crypt to its final position within the oral cavity. At a certain time in development the tooth starts its movement toward the oral cavity. With that movement, the opportunity arrives for factors other than heredity to exert an influence.

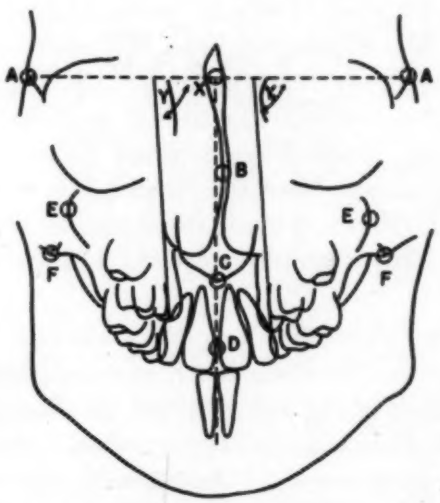

Fig. 3.—Harvold method for measuring asymmetries. (Postero-antero view of the skull.) *A*, Most lateral point on fronto-zygomatic suture; *X*, root of crista galli; *B*, nasal septum; *E*, lateral wall of maxillary antrum; *F*, most inferior point on zygomatico-maxillary suture, and most lateral border of maxilla; *Y*, eruptive angle of inclination.

Initiating Mechanism.—Little is known about the initiating mechanism for eruption. Although several theories have been advanced, none is universally accepted. The time eruption starts may be a genetic matter, too, since there are demonstrable familial tendencies and patterns of eruption. Yet, it is also under endocrine control, for the eruption time serves as an index of the child's maturation. Variations in the start of intra-alveolar eruption, at least for the permanent teeth, are far more likely to be due to local factors than endocrine or other systemic conditions. Markedly delayed eruption, however, does suggest a severe systemic disturbance, for instance, rickets or cretinism.

Direction of Eruption.—The direction of eruption has been studied, but not extensively to date.

An unreported study by Harvold provides an unusual method and interesting preliminary findings (Fig. 3). It should be emphasized that these studies

have been made on postero-anterior cephalometric films. All teeth change their direction of eruption. The central incisors and maxillary first permanent molars normally erupt in almost a straight line. The level of alteration of the path of eruption seems significant, for it appears to coincide with the entrance of the tooth into alveolar bone. Certain teeth show little variability in the path of eruption, while others show a significant range of variation. This is particularly apparent in the mandible for all permanent teeth from the canine distally. Practically all these changes in the angle of eruptive inclination appear prior to the possible influence of such local factors as retained root fragments and unresorbed deciduous teeth. A far better understanding of malformed alveolar arches should be the result when this problem is pursued.

Speed of Eruption.—It should be remembered that three processes are interrelated in eruption—interrelated, but not necessarily interdependent. These are the development of the root, the resorption of the deciduous predecessor, and the growth of the alveolus. Carlson[3] has shown that eruption is not highly correlated to the rate of root lengthening. Nor is the resorption of deciduous roots dependent entirely upon the eruption of the permanent tooth. Finally, as Massler and Schour[11] have pointed out, both the alveolus and tooth are moving in the same direction, but at different rates, and not always simultaneously. In the absence of local factors the speed of eruption seems to be under genetic and endocrine control. There are familial patterns of delayed eruption and certain endocrinopathies (for example, hyperthyroidism) which markedly alter the rate of eruption.

Local Factors Interfering With Eruption.—Among the local factors which may impede or deflect an erupting tooth are such obvious things as supernumerary teeth, cysts, tumors, and retained deciduous root fragments. All of these should be detected in the radiogram, since resorption of the deciduous tooth may not always occur evenly. Occasionally one root of a primary molar resorbs faster than another. This may permit the premolar to tip or rotate to an abnormal position. Complete failure of primary root resorption is sometimes seen. If noticed early, the primary teeth may be extracted carefully without severe malpositioning of the permanent teeth resulting. There is one important exception, the maxillary canine. If a primary molar does not resorb, the premolar is not seriously deflected. If a primary incisor does not resorb the permanent incisor may recover its position, but if a primary maxillary canine does not resorb the permanent canine will likely be deflected out of position. The progress of primary tooth resorption should be carefully followed in the radiogram as a prophylactic procedure in case assessment.

Deciduous root resorption, like eruption, shows alternate periods of rest and activity. During the rest periods a reparative formation of bone and cementum may take place in the resorbed areas, causing a solid joining of bone and primary tooth. This is ankylosis, and usually primary teeth so affected are not exfoliated, but must be extracted. Therefore, they also serve as obstructions to permanent tooth eruption.

Local Factors Hastening Eruption.—Periapical pathology in primary teeth usually means hyperemia and resorption of bone in the region of the lesion. Since there is less bone to erupt through, the permanent successor usually erupts faster.

Eruption Sequence.—Lo and Moyers[9] have shown that certain eruption sequences are characteristic of particular malocclusions. The normal sequence is most likely to provide sufficient space for all the teeth within the arch. Distoclusion cases usually exhibit the eruption of the maxillary molars ahead of corresponding teeth in the mandible. The arrival of the second molar ahead of a canine or premolar is a problem, since there is a strong tendency to close the arch space.

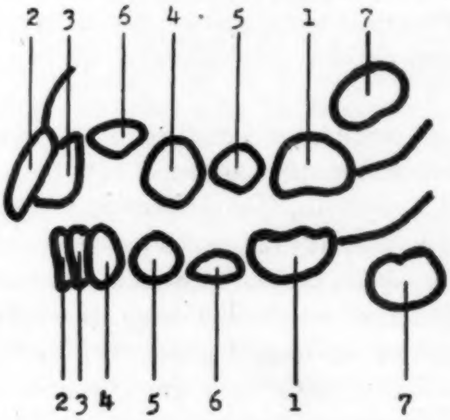

Fig. 4.—Favorable eruption sequence.

Congenitally Missing Teeth.—The failure of a permanent tooth to form will result in natural drifting of the adjacent teeth prior to and during their eruption.

Variation in Tooth Size.—There seems no indication that teeth smaller than the average size have their eruptive paths changed because of their size. Teeth larger than normal, or perhaps even normally sized teeth in small jaws, may begin the process of jumbling before they appear in the oral cavity. When the dental size—arch space ratio is poor, the struggle for that space begins prior to eruption. If the first erupted permanent teeth are unduly large, it is advisable to search the radiogram for malpositions of eruption in the teeth as yet not seen within the mouth. Larger teeth are more likely to arrive out of sequence and out of position.

INTRAORAL ERUPTION

As the tooth crown breaks through the oral mucosa, it enters the potential dental space along the alveolus. This space is bounded horizontally by the tongue, lips, and cheeks, and vertically by the jaw bases. Up to this time, tooth position has been predominately under genetic control, particularly in the case of the deciduous dentition. The break through the oral mucosa in-

troduces the tooth to a complex of environmental forces. Its future position, in fact normal occlusion, now largely depends on a harmonious interrelationship of three entities: (a) the immediate muscular environment, (b) basal bone orientation, and (c) the dental size–dental space ratio.

The Muscle Environment.—In infancy the tongue is the structure nearest adult size in the dentofacial area. It guides to occlusion and normally maintains a continuously spaced deciduous arch up to the outer muscle boundary provided by the lips and cheeks. Later it may direct lingually deflected permanent teeth to their normal position in the dental arch. During the first ten years of life, however, jaw and alveolar growth is proceeding at a faster rate than tongue growth. The resultant relative increase in dental arch size tends to diminish the effects of the powerful tongue support and enhance the effects of the lips and cheeks. Proximal tooth contact then is required in the permanent dentition for dental arch stability to withstand the inward force of the outer muscle band.

Any disturbance of posture or function of the tongue, lips, and cheeks, then, has immediate consequences in terms of eruptive direction of the tooth, dental arch form, and occlusion. The normality of the muscle mold may be disturbed by abnormal habits, disease, or accidents.

Basal Bone Orientation.—Normal occlusion demands well-oriented basal bones (Howes[7] and Jenkins[8]). A basal bone dysplasia, laterally or anteroposteriorly, of a skeletal or positional nature, may disturb muscle posture and function to a degree incompatible with the attainment of normal occlusion. Brodie's hypothesis of a posterior temporomandibular fossa position in Class II cases[2] has recently found support during electromyographic studies. Class II patients with the typical hypertonicity of the posterior temporal muscle fibers exhibited a relatively more posterosuperior condyle and fossa position at 12 years of age than a similar group of 6-year-old Class II children.

Dental Size–Dental Space Ratio.—The condition of abnormal dental size–dental space ratio is rarely of serious import in the deciduous dentition. Since the deciduous dentition is normally spaced, this dental size–space ratio has a mean value less than unity. The upper end of the range is near unity and dental crowdings in the primary dentition are usually minor in degree.

However, in the permanent dentition the value of this ratio is more critical, and more serious dental crowding is seen. Lack of mesiodistal space for the erupting teeth may arise from a local loss of space, or from a general tooth size–space ratio anomaly. The result in each case is impaction or deflection of the erupting tooth by its adjacent fellows. Lo and Moyers[9] have further shown that the normal sequence of eruption tends to be disturbed in segmental space problems. Therefore, these should be studied in the radiogram to better prognose developing malpositions.

The high incidence of tooth size–arch size problems appears to have resulted from a reduction in the dental space available on the alveolus. Certainly teeth have not increased in size. This bony reduction may be associated

with the decreased masticatory function of civilized man. Watt and Williams[13] have demonstrated this phenomenon of reductions of jaw size with reduced masticatory function in rats. Waugh[14] found malocclusion in the first generation of Eskimos living on a civilized diet despite an excellent genetic pattern.

Tooth size is genetically determined and shows only a low correlation with facial dimensions. There is, however, a high correlation in tooth size between individual teeth in the same mouth, that is, a person with large incisors is most likely to have large premolars. Ballard and Wylie[1] and Greiwe[5] have made use of this in devising nomograms for predicting the size of the canines and premolars when the size of the incisors is known.

OCCLUSION STAGE

Muscle Factors.—Nearing the completion of active tooth eruption, the cusps begin to contact and muscle forces acting through the inclined planes become a major factor in deciding final tooth position. Maldirection of an erupting tooth has its final expression at this time in its ability to influence two opposing and two adjacent teeth.

The vertical component of muscle force may reach a figure of several pounds per tooth. This is considerable in the light of tooth-moving orthodontic forces. However, the periodontal membrane is well designed to support this load so long as it parallels the long axis of the tooth.

Under normal conditions, cuspal seating of the permanent dentition occurs concomitantly with the establishment of proximal contact. The larger permanent anterior teeth absorb anterior deciduous spaces and the mesially directed influence of the buccinator at the tuberosity carries the last erupted molar forward to absorb the "leeway space." Final cuspal interdigitation in conjunction with proximal contacting of teeth establishes an arch form of high stability and resistance to deformation.

The anatomic entity of two occluding arches is maintained by two groups of physiologic influences. In the horizontal plane, forward directive influences are the tongue, the buccinator at the tuberosity, and the anterior component of occlusal influence. These are resisted by the horizontal muscle band of the lips and cheeks containing the dental arches. In the vertical plane, the teeth are maintained up to the level of the occlusal plane by the alveolar growth influence. This is continuous throughout life.

Any possible tendencies of alveolar growth to force the jaws apart are controlled by the vertically acting masticatory muscles. These antagonistic influences are in equilibrium at the jaw position of occlusal contact, which is a few millimeters closed from the position when the muscles are at physiologic rest. This interval is called by Thompson[12] "freeway space." Hypertonic musculature or loss of tooth support may disturb this equilibrium and cause jaw overclosure and increased "freeway." The normal interval or freeway of a few millimeters apparently is provided to ensure cusp clearance at the physiologic rest position. Thus, changes in mandibular position with changes in bodily posture cannot apply force to the teeth through the cusps to cause

unnecessary strain of the dental supporting structures. This "freeway" then permits the mandible its functions as a postural and airway protective unit without throwing unnecessary stress on the dentition.

Tooth Attrition.—Normal occlusion in the deciduous dentition is established by the age of 3 years. The teeth are continuously spaced in two parabolic arches, and present unworn cusps occluding in the classical relations described by Friel.[4] This dentition responds to a highly functional environment by occlusal wear. Reduction in cusp height and wider range of mandibular function thus is permitted, allowing a less fettered forward growth of the mandible. Moyers[10] has shown that Greek children living on coarse diets showed markedly altered occlusal relationships between the ages of 3 and 6.

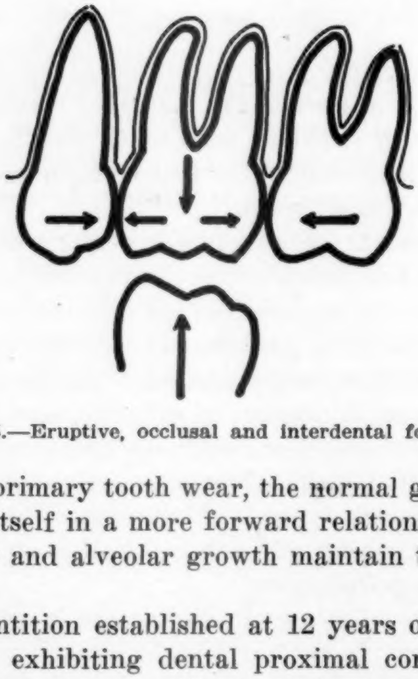

Fig. 5.—Eruptive, occlusal and interdental forces.

This means that, with primary tooth wear, the normal growth of the mandibular bone may express itself in a more forward relationship to the upper face. Despite this wear, jaw and alveolar growth maintain the teeth up to the occlusal plane.

The permanent dentition established at 12 years of age differs from the deciduous dentition in exhibiting dental proximal contact relations. It responds to a favorable functional environment by occlusal and interproximal wear. Dental proximal contact areas up to 9 mm. in buccolingual width are seen in Australian aboriginal dentitions. Despite this wear, the adjusting influences of continuous alveolar growth and mesial drift maintain cuspal and interproximal contact relations. The effect of interproximal wear in flattening proximal contact areas enhances arch stability to resist arch-collapsing forces. This is a desirable effect to compensate for some loss of interarch support associated with cuspal wear.

SUMMARY

Case assessment is dependent upon the position of the tooth at the time the case is first seen. The tooth matures through four physiologic stages of development. Different forces are operable at each stage.

This paper has attempted to summarize the physiologic influences during these four stages of development.

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TREATMENT OF A TYPICAL DISTOCLUSION CASE

DONALD C. MACEWAN, D.D.S., SEATTLE, WASH.

THE purpose of this article will be not so much to describe a definite technique with a specific appliance as used in a representative case, but rather to offer a time-tested, logical procedure, based on realistic case analysis, to which most of the currently popular orthodontic mechanisms may be adapted with a little ingenuity.

GENERAL CONSIDERATIONS

The term "typical distoclusion" can be, and often is, quite misleading. In fact, there is about in my mind whether there is a definite entity which can be called a "typical distocclusion," for the following reasons:

1. The term "distoclusion" classifies malocclusion in only one of three dimensions. All cases could be classified with equal validity in the vertical dimension as open-, nomal-, or close-bites; or in the transverse dimension as narrow, normal, or wide arches, individually or in combinations of widths.
2. The term "distoclusion" specifies only a certain anteroposterior relationship of the crowns of the molars (and perhaps premolars) in opposing arches, and thus puts into one package a great variety of dysplasis and malrelationships, in this dimension alone, which must be considered in arriving at a differential diagnosis and an appropriate treatment plan. This concept should be taken into account, likewise, in the vertical and transverse dimensions.*
3. A survey of the last 700 consecutive cases in my practice revealed that no one variety of distoclusion was sufficiently predominant to be called "typical," nor sufficiently distinctive to merit that designation, with the possible exception of Class II, Division 2 (Angle).

Treatment planning, including appliance design and proposed manipulation, therefore, should be directed in each individual case toward the establishment of a functionally occluding denture, so situated *in three dimensions* as to be in physiologic (and, if possible, cosmetic) harmony with its osseus and muscular environment.

TREATMENT PLANNING

Charles F. Kettering has said, "A problem well stated is a problem half solved."

Read before the American Association of Orthodontists, Dallas, Texas, April 29, 1953, as part of a symposium entitled "Treatment of a Typical Case of Distoclusion of the Teeth."

*For detailed information on these points, the reader is referred to the excellent writings of Bercu Fisher on the "individuality hypothesis" and of Wylie and Johnson on anteroposterior dysplasias.

A Pacific Fleet admiral is credited with the following creed: "Give us the courage to accept with serenity that which cannot be changed; give us the strength to change that which can and should be changed; and give us the wisdom to distinguish the one from the other."

These two quotations contain the active ingredients of treatment planning—first, a recognition of the precise nature of the problem presented by each case and, second, determination of the best means of preserving the desirable and correcting or improving the undesirable features of the case.

While our growing knowledge of form and function makes it increasingly apparent that treatment planning must be individualized, certain physiologic principles as related to morphologic standards point to a logical approach to a well-stated problem.

Thompson and others have shown that the rest position of the mandible, the starting point of function, is physiologically constant. We should not attempt to change that orthodontically, but rather should accept and preserve it, lest we produce "dual bites," anteroposterior or lateral displacement of the mandible in centric occlusion, or abnormal freeway space, all of which are detrimental to the patient and may jeopardize the stability of the corrected occlusion.

It is generally accepted that, for stability, the mandibular teeth should be situated within certain limits in their relation to the body of the mandible. This may or may not require change by the orthodontist. The predetermination of the optimal relationship of mandibular teeth to bone should be based primarily upon the muscular and occlusal forces which will maintain stability in the corrected denture, rather than upon statistically determined morphologic norms. In no case should a stable relationship with compatible arch form be disturbed, except when it is obvious that its proposed new environment will reduce its stability.

Should change be required in the mandibular denture, the timing of such correction (whether before, during, or after correction of the maxillary denture) and the planning of appliance therapy are not within the scope of this short article. It may be stated, however, that the objectives should be stability in its new environment and from that will accept the articulation of the maxillary denture.

To recapitulate, we have no choice in the placement of the body of the mandible, the rest position determining its proper location. We then determine the optimal position of the mandibular teeth with respect to that bone.

It then remains for us to decide upon the best means of placing the maxillary teeth in articulation with the lower denture.

The variety of distoclusion assigned for this symposium may have a stable relation of the mandibular teeth to the body of the mandible in acceptable arch form. In such cases, the problem is reduced to that of articulating the maxillary teeth to the mandibular denture when it functions normally from rest position.

This may involve (1) retraction of all maxillary teeth; (2) removal of dental units, plus retraction of the teeth anterior to the space so created;

(3) obviating distal displacement of the mandible; or (4) a combination or these.

The case selected for illustration falls in the first category, retraction of maxillary teeth. The appliances and techniques to be shown have been used for eight or ten years by members of the Pacific Northwest Orthodontic Study Society, with consistently satisfactory results.

APPLIANCE THERAPY

The anchorage used for maxillary retraction is a lower lingual wire from last molar to last molar, of 0.030 inch or 0.036 inch hard chrome alloy, rigidly attached to the molar bands, and passively adapted to contact with each tooth as far gingivally as possible.

Brodie[1] has said repeatedly that the best available anchorage is the undisturbed tooth. Dillon[2, 3] has advised "the greatest number and stability of resistance units against the least number and stability of units to be moved." The most stable anchorage, therefore, is provided by the greatest possible number of undisturbed teeth.

In our use of the lingual wire as anchorage, the mandibular teeth are undisturbed at the beginning of intermaxillary traction, and remain undisturbed so long as the need for intermaxillary traction exists. This is possible because the amounts of force used are kept below the stability limit, which is about 7 Gm. per square centimeter of root surface (or, more precisely, per square centimeter of alveolar lamina dura) if the periodontium is physiologically normal.

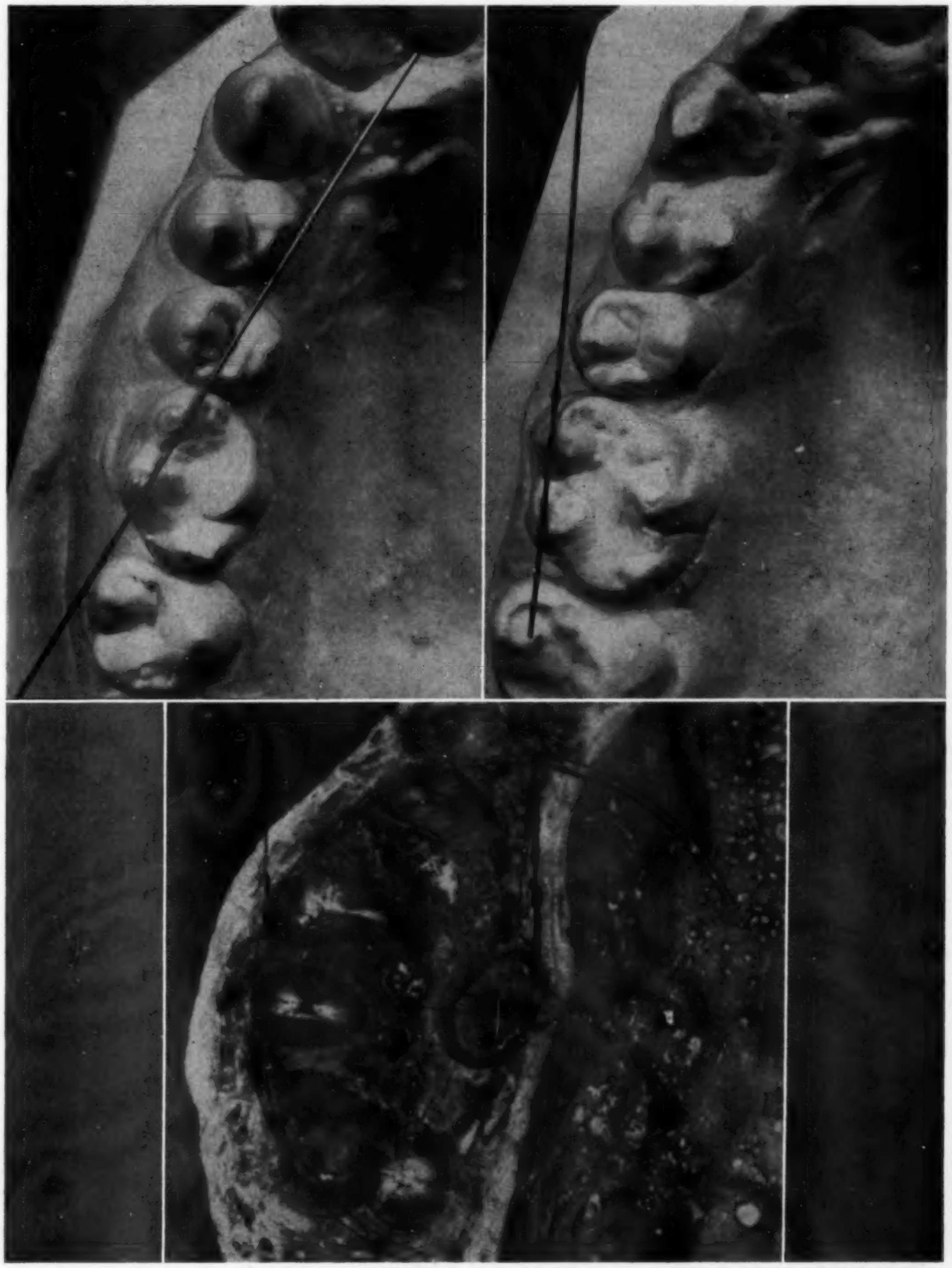
This figure, which has been determined from routine measurements of stresses made in the mouth over a period of years, represents roughly the extent to which a constant force may be applied to undisturbed teeth without initiating tooth movement. Use of force in excess of this amount may activate the periodontal tissues and initiate tooth movement. As soon as this process has started, a much lesser force is required to continue movement in the same direction, and the effectiveness of the anchorage units is reduced.

Your attention is directed especially to the amounts of force used in the various steps of this treatment. Where tooth movement is desired, the light forces used exceed the stability limit just mentioned, but do not exceed the capillary blood pressure, which is 20 to 25 Gm. per square centimeter. Where tooth movement is not desired (that is, for anchorage), the force is kept below the stability limit.

Since the active and reactive forces are equal—for instance, the total traction is equal at both ends of an intermaxillary elastic—the force per unit of resistance is controlled by its distribution to a greater number of teeth for anchorage and a smaller number of teeth to be moved.

It should be borne in mind that the absolute quantity of force required will depend upon several factors, including the size of the tooth roots. All figures given are estimated averages.

A. B.



C.

Fig. 1.—*A*, Mesial rotation of maxillary molar; *B*, normal position of maxillary molar; *C*, axis and path of rotation. (Courtesy of Spencer R. Atkinson.)

In physiologically normal bone, the undisturbed lower denture, united by means of the passive lingual wire described previously, is capable of withstanding about 85 Gm. (3 ounces) of intermaxillary traction on each side. So great a force, however, is never necessary or advisable, as will be shown, since the maxillary teeth are retracted singly or in small groups.

In most maxillary protractions the upper molars are rotated forward (Fig. 1, *A*), the axis of rotation being the lingual root, and the buccal roots following an arc around this axis (Fig. 1, *C*).

The logical treatment, therefore, is to replace the molars singly in their normal positions (Fig. 1, *B*) by reversing these rotations.

This is accomplished with the "buccal bar" (Fig. 2, *A*), a rigid 0.036 inch chrome alloy wire attached only to the buccal surface of the molar band, the mesial end of the wire being free of attachment except to the intermaxillary

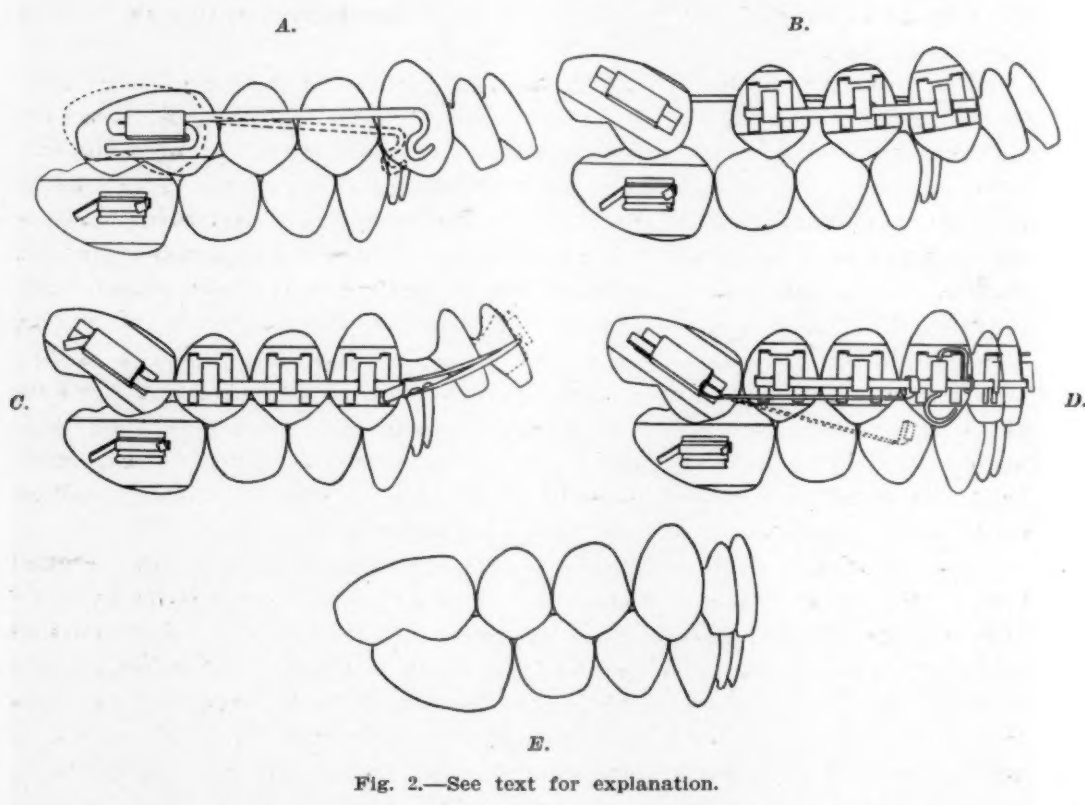


Fig. 2.—See text for explanation.

elastics. With this "free-wheeling" appliance, the intermaxillary elastics rotate the molars in the stipulated manner, and also tip their crowns distally. This is intentionally overdone until their mesial marginal ridges occlude in or distal to the buccal grooves of the lower molars (Fig. 2, *B*). Their axial inclination must be corrected later in treatment, as described in the following paragraphs.

One and one-fourth to 2 ounces of intermaxillary traction is adequate to effect this movement if there is no great resistance from cusp interference.

The only adjustment of the buccal bar is the return of its mesial end to a comfortable and mechanically advantageous position at three-week intervals (Fig. 2, *A*).

When the molars have been sufficiently retracted, they are temporarily held in that position with either a lingual wire or an acrylic palate, so designed as to offer no resistance to the retraction of the premolars.

These latter (or if the roots are not disproportionately large, the premolars and canines) are now retracted as a group (Fig. 2, *B*), using intermaxillary traction not to exceed 2 to 2½ ounces, until the canines are well seated in their opposing embrasures (Fig. 2, *C*). Bodily movement or axial positioning should be avoided at this time, but these teeth may be banded for the correction of rotations only.

Once retracted, these teeth are held in position with a passive wire pinned into the brackets and adapted passively into the molar attachments, with stops as its mesial and distal ends (Fig. 2, *C*). The intercuspation also aids in retention at this point.

The retraction of the maxillary incisors, because of their relatively small roots, may be accomplished with a light force of 1 to 1¼ ounces on each side, by passing a light elastic or tandem elastics from canine to canine. The forward component of this elastic force is counterbalanced by an equal tension with intermaxillary elastics (Fig. 2, *C*). The incisors are permitted to follow the course of least resistance, being banded only to prevent impingement of the elastics on the gingivae or to accomplish rotations with light round wires (0.010 inch). The upper lingual wire (or the acrylic palate) is, of course, removed during the retraction of the incisors. Such interferences as perverted tongue or lip pressures must be eliminated (Whitman[6]), and blocking of the upper incisors against the incisal edges of the lowers may need to be avoided by use of a "bite-raiser" (Lloyd Chapman, unpublished ABO thesis 1952). The latter is only occasionally necessary, however, since the retraction of the buccal segments usually corrects a deep overbite.

The maxillary molars, which are still tipped distally, are now "cocked back" (Fig. 2, *D*) using a rectangualr spring wire, not over 0.012 by 0.028 inch, attached to the molar's buccal surface. A portion of this wire is twisted on its own axis so that its wide dimension lies in the horizontal, instead of the vertical, plane. (It is twisted from the ribbon arch to the edgewise arch position.) The horizontal section of the wire gives vertical flexibility, so that a gentler force will act over a longer range, and accomplish the required tooth movement with fewer adjustments, within the recommended range of forces.

The attachment of the mesial end of these springs varies, depending on the need for distribution of the occlusalward reactive force. It may be used to elongate single teeth by ligation to brackets; or small groups of teeth by hooking it over short segmental wires; or it may be so distributed over the incisors, canines, and premolars as to cause virtually no elongation of these teeth (Fig. 2, *D*).

There is an anterior component of force as the molar roots are moved distally, which would tend to drive the premolar and anterior teeth forward. This

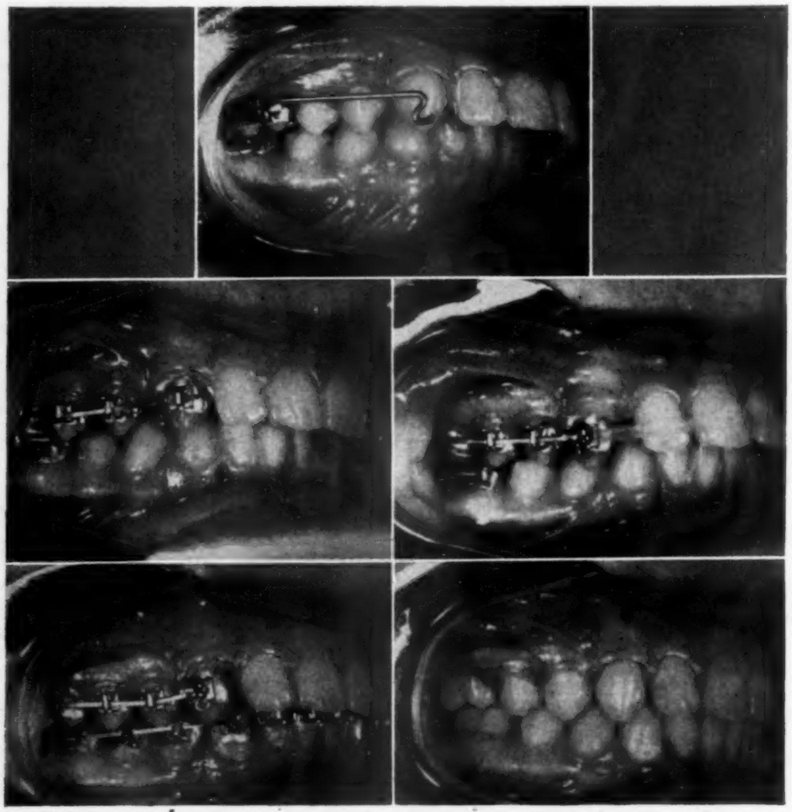
is counterbalanced by intermaxillary traction of only sufficient strength to prevent unwanted movement—usually about 1½ ounces. Axial positioning and rotation of upper premolars, canines, and incisors are completed during this phase of treatment, using standard universal bracket or other methods.

When the need for intermaxillary elastics no longer exists, the stability of the lower anchorage may be reduced or destroyed by banding additional mandibular teeth to effect rotations, axial positioning, and minor changes in arch form, if they are needed. Let me repeat that the mandibular teeth should not be disturbed so long as they are needed for anchorage.

Finally, all but the molar and lateral or canine bands are removed, the band spaces closed by means of traction coils or "hugging wires," and conventional retainers used for postoperative maintenance. The desired articulation is shown in Fig. 2, *E*. Note especially the position of the distobuccal cusp of the upper molar.

A.

B. *C.*



D. *E.*

Fig. 3.—See text for explanation.

A case illustrating the procedures advocated in this article is shown in Fig. 3. Fig. 3, *A* shows the buccal bar at the beginning of treatment. Intermaxillary elastics (2 ounces) were used to the lower first molars, a passive lingual wire distributing the force to all the mandibular teeth. Fig. 3, *B* shows the

maxillary molar rotated and tipped distally so its mesial marginal ridge occludes just distal to the buccal groove of the lower molar. The upper molar was held in this position with a lingual wire. Note the tendency of the premolars and canines to follow along due to tension on the interdental ligaments. The premolars and canines were banded and connected by a 0.008 by 0.028 inch wire whose mesial end provided attachment for intermaxillary elastics (2 ounces).

Fig. 3, *C* shows the premolars and canine retracted until the latter is seated in its opposing embrasure. Note the clearance between the canine and incisors, permitting the latter to be readily tipped backward into position. Also shown here is the very light (1½ ounce) elastic running from canine to canine, with which this was accomplished. No maxillary incisor bands were needed in this case.

"Cocking back" of the molar was begun during this stage, but without the horizontal twist in the wire. This was doing it the hard way, because smaller and more frequent adjustments were necessary. Intermaxillary elastics (2 ounces) counterbalanced the anterior components of force in the maxillary appliance.

Fig. 3, *D* shows the maxillary denture in virtually its final form and the mandibular teeth banded to flatten the curve of Spee and align the individual teeth. Here we see two 0.010 inch arch wires pinned in the brackets.

Fig. 3, *E* shows normal overbite and overjet in the completed case, permitting good function, and acceptable articulation, including proper axial inclination of the molars.

The occlusion has remained stable four years out of retention, notwithstanding a previous unsuccessful treatment by another orthodontist.

COLLATERAL COMMENT

1. The type of malocclusion under discussion (maxillary dental protraction) is more effectively treated in two stages. First, in the early mixed dentition, with merely the passive lower lingual wire and buccal bars, the molars are retracted and the deciduous premolars and canines tend to follow along. The incisors then are retracted, using light elastics from buccal bar to buccal bar, counterbalanced by intermaxillary elastics. Except for the distally tipped molars, normal occlusion can be attained in about four to six months. A Hawley type of retainer is worn until the permanent premolars and canines have erupted. Meanwhile, the eruptive force has been carrying the maxillary teeth in a path toward normal, rather than toward further protraction. In the second stage, the molars are "cocked back," and rotation of premolars and canines is accomplished if necessary.

2. During the early mixed dentition, the pterygoid process of the sphenoid bone lies medial to the tuberosity of the maxilla. By the early teens, the lateral growth of this process has placed it behind the tuberosity, to partially or completely block further distal eruption of the molars—another reason for early treatment of these cases.

3. The use of the light forces recommended herein will move unobstructed teeth at about the same rate as heavier forces. Moreover, the removal of obstructive etiologic forces being essential to permanently successful treatment in any case, the perseverance of such etiologic forces is more readily disclosed if the teeth fail to respond to gentle treatment.

4. The use of a suitable strain gauge is essential in delivering the proper "dosage" of force to the teeth.

5. No discomfort should be experienced by the patient after the one- or two-day hyperemia at the beginning of each phase of treatment. There is no reason for being unkind to the teeth and supporting tissues, when gentle treatment, if well planned, can be just as effective.

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FOURTH AND PIKE BLDG.

TREATMENT OF A CLASS II MALOCCLUSION IN MIXED DENTITION WITH THE USE OF REMOVABLE APPLIANCES

S. D. Gore, D.D.S., New Orleans, La.

IN PRESENTING the following case report we have selected a typical distoclusion, as requested by your program chairman, who further suggested a case of mixed dentition with narrow arches in the anterior segment.

The patient is a boy, 8 years of age, weight 57 pounds, height 54 inches, and a mouth breather. His oral health and general health are good. X-ray examination showed very little root absorption of the deciduous molars and cuspids. All his permanent teeth were present and in relatively normal positions.

Even though you all may not agree that this is the proper time for treatment of this type case, it has been our observation that better facial harmony is produced if treated at this time. By correction of the arch malrelation, alignment of teeth, and establishing the function of teeth and muscles, the patient has several years of correct usage of teeth and muscles, which aids in bringing about a better harmony.

Treatment of this type case at this time usually has to be done in two periods of treatment, as will be described.

The appliance used was a precious metal removable type known as the Crozat Appliance. In cases where no root absorption of the deciduous molars has occurred, we always use the second deciduous molars for anchor teeth. Bent-wire clasps were made for these four molars, and removable appliances were constructed. Only the lingual parts were placed in the beginning, for molar rotation and expansion. After this had been accomplished, a high labial was added with finger springs to the individual teeth. Intermaxillary elastics were employed to correct the mesiodistal relation of the arches.

Appliances were placed on June 28, 1946, and the patient was treated until Aug. 26, 1947, making a total of fourteen months for this primary treatment.

He wore these same appliances at night only until December, 1948, at which time he lost two of his second deciduous molars and we advised extraction of the other two. All appliances were removed and the patient was kept under observation until Nov. 18, 1950, at which time clasps were made for his four six-year molars and the appliances changed.

Treatment was continued until Sept. 15, 1951, when he was instructed to wear appliances at night only. The total time of active treatment was twenty-

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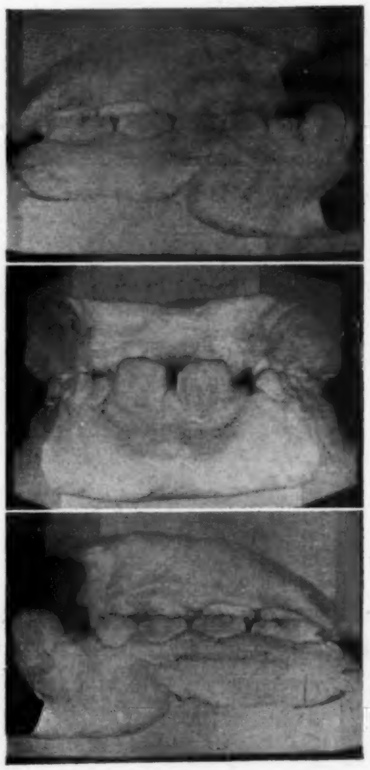
Fig. 1.—Facial views before treatment.

Fig. 2.—Facial photographs after completion of treatment.

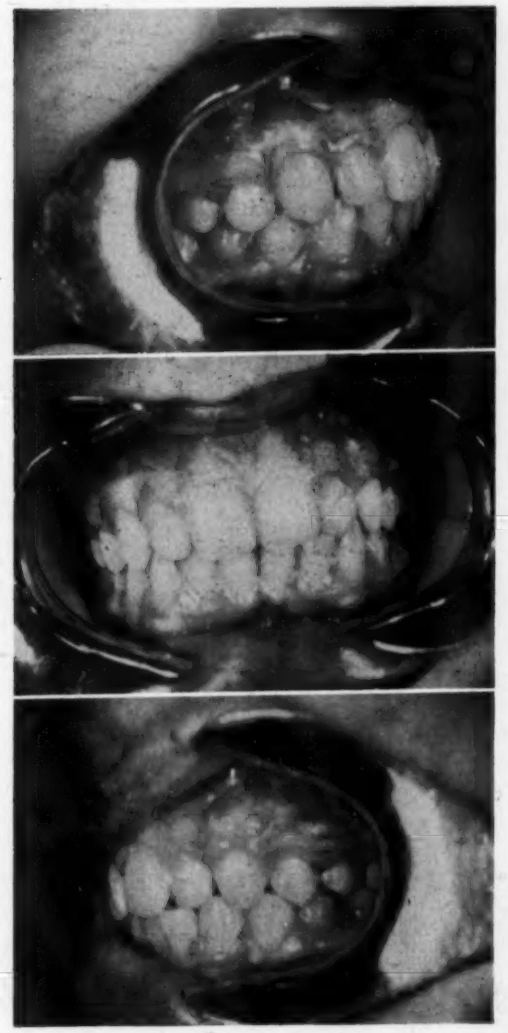


A.

B.

C.

Fig. 3.



A.

B.

C.

Fig. 4.

Fig. 3.—Models before treatment.
Fig. 4.—Teeth after treatment.

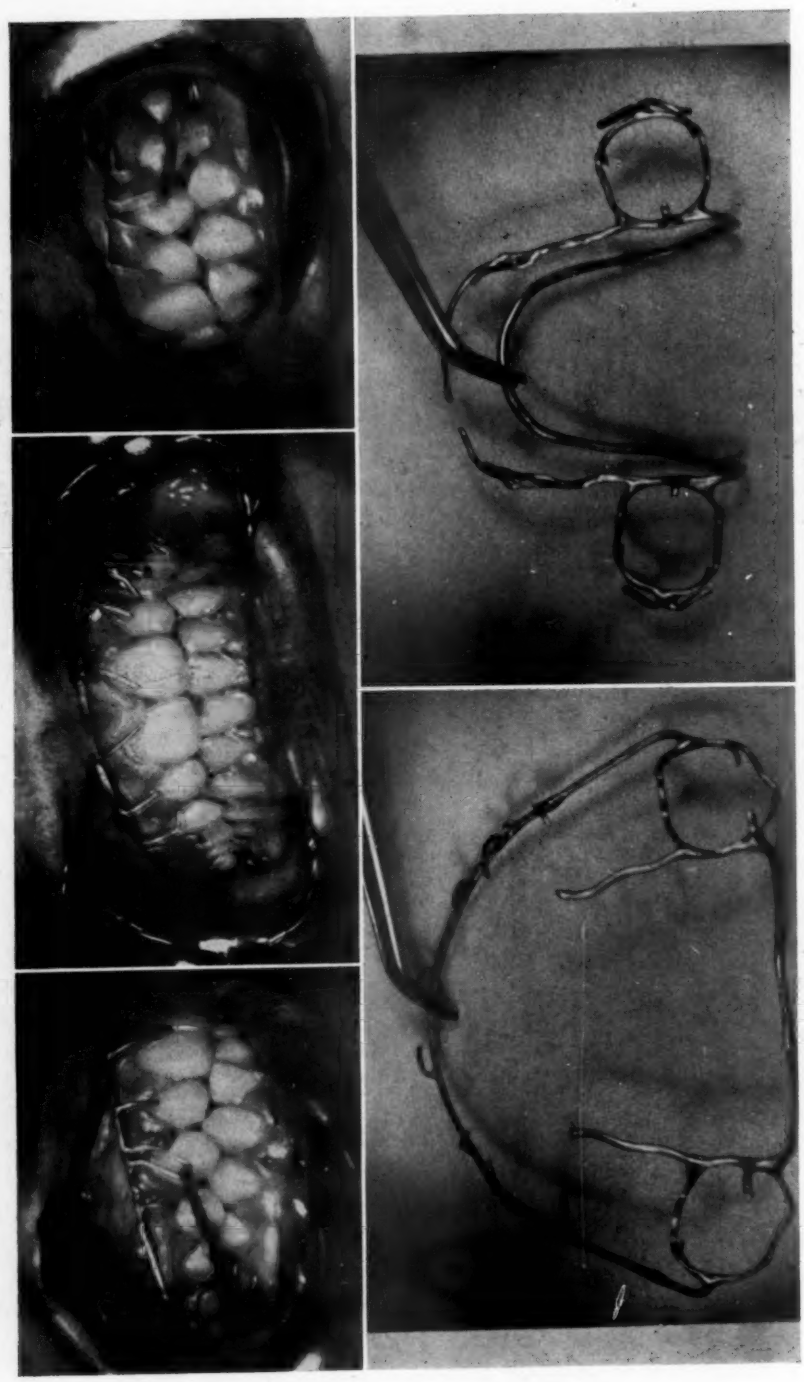


Fig. 5.—Appliances in place and views of appliances.

four months, during which time the patient was seen thirty-four times. The average time for each appointment was about six minutes. Between primary and secondary treatments, he was observed at two-month intervals.

At the time secondary treatment was started, the patient showed some crowding of his lower incisors. We think this was because his growth and bone changes had not progressed as rapidly as his treatment. Had his treatment been slower, the growth would have kept pace with the tooth movement.

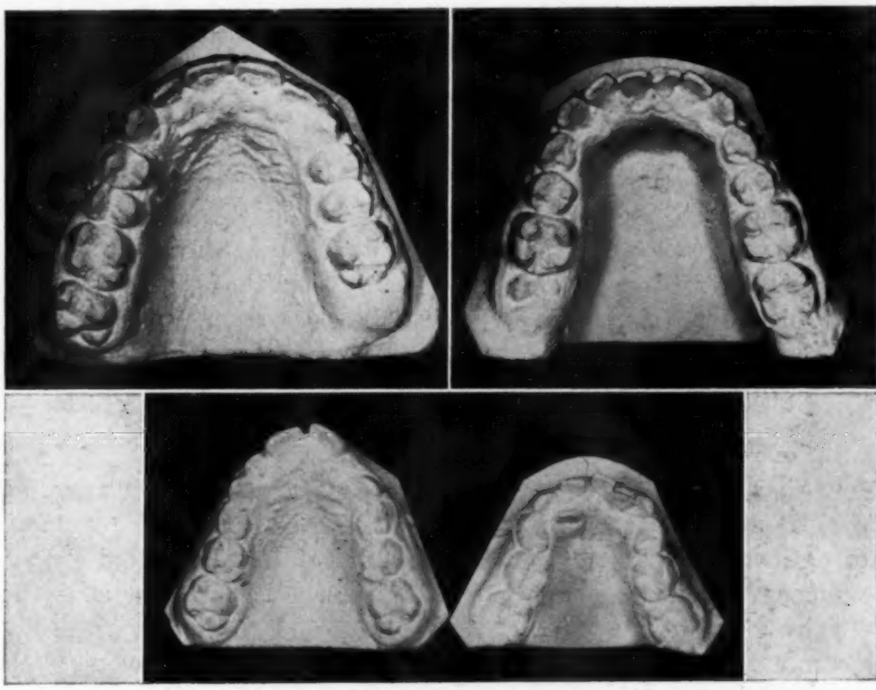


Fig. 6.—Occlusal views of models before and after treatment.

His final facial photographs are still those of a youth, and when he has reached adult age the change in facial balance should be greater than shown.

In our opinion, the time consumed for treatment of this type case at this age is less than if treated later and, as stated previously, the results in facial harmony are much better.

1237 Maison Blanche Bldg.

CHANGES IN THE LAMINA DURA DURING TOOTH MOVEMENT

MAURY MASSLER, D.D.S., M.S., CHICAGO, ILL.

INTRODUCTION

THE *lamina dura* is a term commonly used by the dental roentgenologist to describe that narrow portion of the alveolar bone which borders upon the periodontal membrane and which appears in the roentgenogram as a well-defined, radiopaque (white) layer. The term *lamina dura,* meaning "hard layer," is derived from the fact that it is more radiopaque than the adjacent bone (Fig. 1).

The purpose of this article is to describe changes in the roentgenographic appearance of the lamina dura during various types of tooth movements, such as occurs during eruption, drifting, and orthodontic procedures.

METHODS AND MATERIALS

More than 1,000 full-mouth roentgenograms were examined carefully with the aid of a hand lens at a magnification of about 6 times. The roentgenograms were of patients from 2 years of age to adulthood. Two hundred complete sets of roentgenograms were of patients treated in the Department of Orthodontia and by private practitioners.

A study also was made of the roentgenograms and histologic sections of sixteen human jaws ranging in age from birth to adulthood.*

FINDINGS

Changes in the Lamina Dura During Eruption.—Examination of the lamina dura in the roentgenograms of children showed that the appearance, structural characteristics, and degree of radiopacity of the lamina dura correlated exactly with the rate of eruption of the teeth.

From the moment the bony crypt appeared in the roentgenogram until the tooth was in full clinical occlusion, the lamina dura presented the appearance of a thick and distinctly radiopaque border immediately surrounding the tooth (Fig. 1, *A* and *B*). At the same time, the space occupied by the periodontal membrane (or the dental sac) was characteristically wide. During the stages of active eruption the density of the lamina dura was as great as the much thicker and more highly calcified dentine in the same film (Fig. 1, *A*). The area of the thickened and radiopaque lamina dura corresponded exactly with the area of rapid bone formation as seen in histologic sections.

From the University of Illinois, College of Dentistry, Department of Pedodontics, Chicago, Ill.
*Made available through the courtesy of Drs. J. P. Weinmann and H. Sicher.

As the tooth achieved full clinical occlusion and the rate of eruption slowed down, the lamina dura became thinner and much less radiopaque (Fig. 2). The periodontal membrane also became narrower. This was particularly apparent when the teeth of the same individual were followed roentgenographically over a period of time. One could readily follow the gradual loss in the thickness and the radiopacity of the lamina dura in the radiograms as the clinical eruption of the tooth progressed. As it became thinner, the radiopacity of the lamina dura also became less obvious until it approached the density of the surrounding bone.

The thickness and radiopacity of the lamina dura continued to diminish after the tooth reached full clinical occlusion and as the individual became older. However, the lamina dura did not disappear altogether, even in persons past 40 years of age. The lamina dura was still present (but not very prominent) in the roentgenograms of healthy older individuals with good

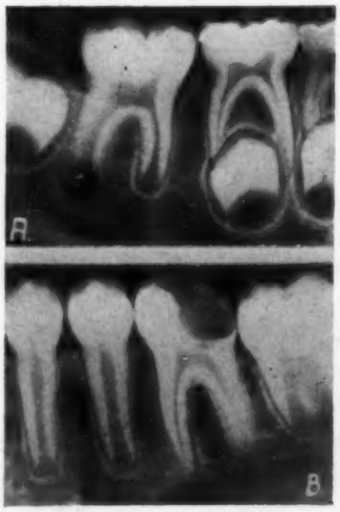


Fig. 1.—*A*, Intraoral roentgenogram of a 6½-year-old child. Note the dense and wide lamina dura around the erupting first permanent molar and around the crypts of the developing premolars and second molar. Compare with the lamina dura around the roots of the primary second molar. *B*, Intraoral roentgenogram of a child 11½ years of age. Note the dense and wide lamina dura around the roots of the erupting premolar and second molar. Compare with the lamina dura around the completely erupted first permanent molar.

occlusion. This probably is due to the fact that the alveolar bone proper continues to grow as a result of function and the passive eruption of the teeth, although the rate decreases constantly with age.[3]

Changes in the Lamina Dura During Drifting.—

Broken contacts: Teeth often tend to shift quite markedly when the contact areas are destroyed by interproximal decay. In Fig. 3 caries has destroyed the distal portion of a lower first permanent molar and the first molar has tipped distally into the resulting space. The lamina dura is thick and prominent and the periodontal space is wider at the mesial surface of the mesial root in its gingival two-thirds. This corresponds to the area of apposition of new bone in histologic section as has been shown by Kronfeld.[3] Note

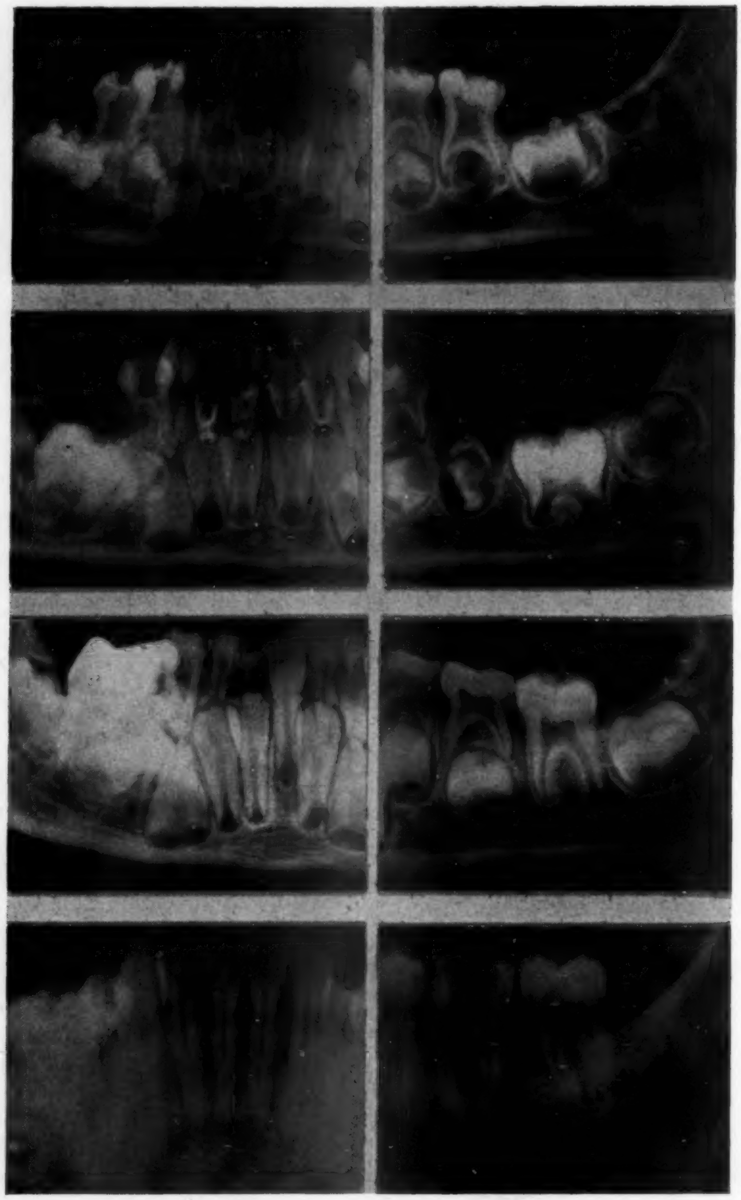


Fig. 2.—Roentgenograms of jaw specimens showing the characteristic changes in the lamina dura during the different stages in the eruption of the teeth. Note the lamina dura lining the bony crypt around the developing tooth, its thickness and radiopacity as long as the tooth is actively erupting, and the loss in prominence when the tooth is fully erupted. (In the 4½-year-old specimen, the primary incisors are held in place with a radiopaque cement.)

Fig. 3.—Roentgenogram of a jaw specimen showing tooth movement as a result of broken interproximal contact caused by caries. The first molar is tipped distally about a fulcrum near the apical third of the distal root, while the second molar has drifted mesially without tipping. Note the prominent lamina at the areas of apposition (side of tension) and its disappearance on the surfaces which histologically show resorptions (side of pressure).

that the tipping movement has occurred around a fulcrum located near the apical third of the distal root. Note also that the second molar has migrated mesially to occupy the space caused by the decayed portion of the first molar. The lamina dura is thick and prominent, and the periodontal space is wider along the distal aspect of the distal root, and the lamina is absent along the mesial aspect of the mesial root. These areas correspond histologically to the areas of new bone formation and bone resorption, respectively.

Changes such as these (tooth movements as a result of broken contacts) were observed often at all ages in this series of roentgenograms. It was striking to note how clearly the roentgenographic appearance of the lamina dura reflected such tooth movements.

"Elongated" teeth: The removal of an antagonistic tooth frequently results in an "elongation" or supraeruption of a tooth. In such instances the lamina dura becomes accentuated in thickness and radiopacity during the period of occlusal movement.

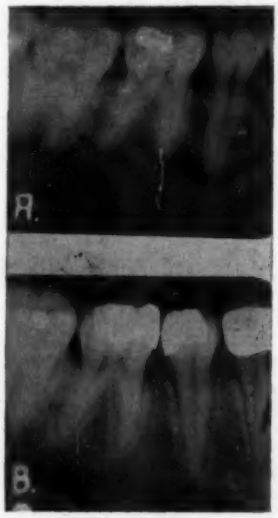


Fig. 4.—Intraoral roentgenograms of the molar area (*A*) before and (*B*) after orthodontic treatment. Note the increased width and density of the lamina dura as a result of the orthodontic tooth movement. Note also the increased trabeculations of the supporting bone as a result of the restoration of normal function of the teeth. (Courtesy of Dr. A. Goldstein.)

Changes in the Lamina Dura During Orthodontic Tooth Movements.—A truly experimental analysis of the changes in the lamina dura during tooth movement can be made by means of the intraoral roentgenograms taken during orthodontic treatment. The findings in this study were in complete agreement with those published by Rehak in 1935.[5]

Before orthodontic treatment was instituted, most roentgenograms showed a lamina dura of the usual thickness and radiopacity (Fig. 4, *A*). During the period of tooth movement the lamina dura became distinctly wider and more radiopaque on the side of tension and disappeared on the side of pressure (Fig. 4, *B*). The periodontal membrane at the same time became distinctly

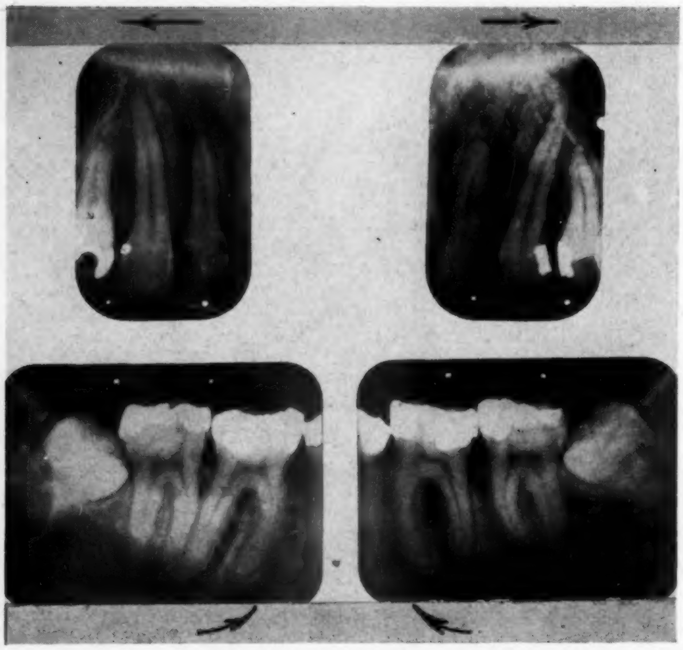


Fig. 5.—Intraoral roentgenograms of a patient undergoing orthodontic treatment. The upper canines and lateral incisors were moved bodily in a distal direction. Note the very wide lamina dura on the mesial surface of the alveolus and its absence along the distal surface. The lower first molars were tipped distally and occlusally around a fulcrum near the apex of the distal root. Note how the lamina dura indicates the direction of tooth movement and sites of new bone deposition. The arrows indicate direction of tooth movement. (Courtesy of Dr. A. Goldstein.)

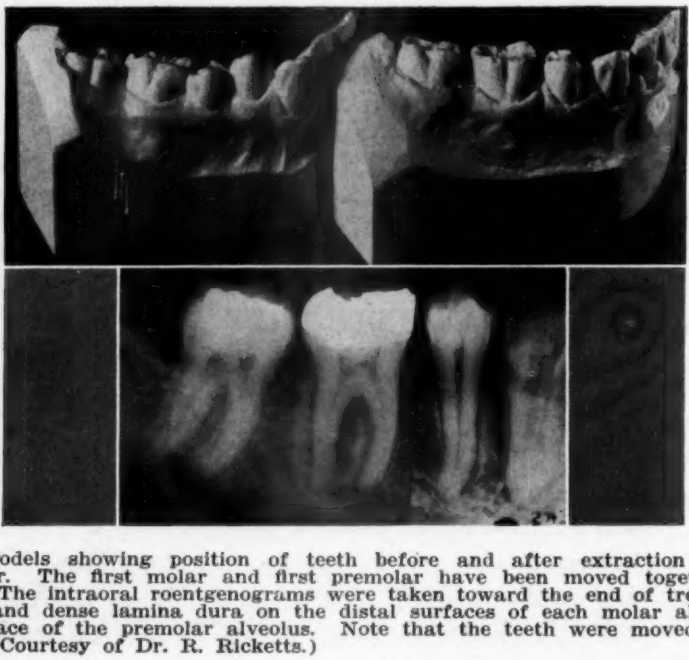


Fig. 6.—Models showing position of teeth before and after extraction of the lower second premolar. The first molar and first premolar have been moved together by orthodontic means. The intraoral roentgenograms were taken toward the end of treatment. They reveal a wide and dense lamina dura on the distal surfaces of each molar alveolus and on the mesial surface of the premolar alveolus. Note that the teeth were moved bodily, without tipping. (Courtesy of Dr. R. Ricketts.)

wider on the side of tension and very thin on the side of pressure as in Figs. 5 and 6. Thus, the surface upon which new bone formation was taking place as a result of the tensions induced in the periodontal fibers during the orthodontic procedure showed a wider and more radiopaque lamina dura. The surface toward which the movement was progressing (that is, the side of pressure where resorption was taking place) showed a lamina dura that became thinner and finally disappeared. These changes in the lamina dura, and in the width of the periodontal membrane, could be detected easily a few days after tooth movements were instituted.

Fig. 7.—Intraoral roentgenogram showing the wide and dense lamina dura formed on the side of tension during orthodontic tooth movement. The first molar is being brought upright by moving the tooth occlusally, with a very slight distal tipping. The premolars are being moved bodily in a mesial direction. Note the resorption bays and the disappearance of the lamina dura on the side of pressure. (Courtesy of Dr. A. G. Brodie.)

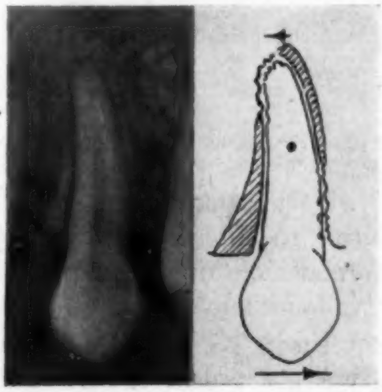


Fig. 8.—Intraoral roentgenogram of an upper canine whose crown is being tipped distally by orthodontic means. The diagram indicates the fulcrum (dot), the direction of crown and root movements, the sites of new bone deposition as indicated by the increased width and density of the lamina dura, and the areas of resorption as indicated by the resorption bays in bone and cementum and the disappearance of the lamina dura.

Changes in the lamina dura also clearly revealed the type of tooth movement that occurred, that is, whether the tooth had been tipped or moved bodily, and in which direction. Figs. 6 and 7 illustrate the roentgenographic appearance of the lamina dura during bodily movement of teeth, while Fig. 8 illustrates the changes in the lamina dura during tipping movement.

All types of movements in the mesial and distal directions were easily and clearly revealed by the characteristic changes in the roentgenographic

appearance of the lamina dura. However, movements in the buccal and lingual directions could not be analyzed with certainty, as the shadow of the tooth obscured the changes in the alveolar process.

Changes during retention: During the period of retention following active tooth movement the surface of the bony crypt, which was resorbed during active treatment and had lost its lamina dura, is now filled in with new bone. Roentgenograms taken shortly after tooth movement was completed showed a thick, distinctly radiopaque lamina dura on the surface of the alveolus that was resorbed during the treatment (Fig. 9). The site of pressure (resorption) during tooth movement becomes the site of new bone formation during the period of retention. Thus, the roentgenographic picture of the lamina dura tends to become reversed during the retention period but indicates again, clearly, the area of new bone formation.

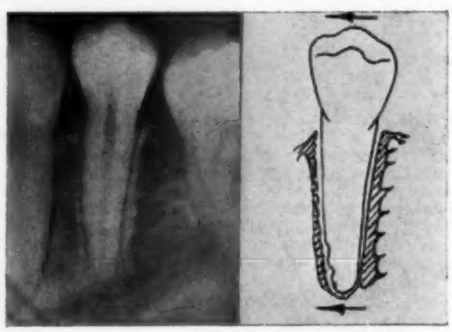


Fig. 9.—Intraoral roentgenogram of a lower premolar which had been moved bodily in a mesial direction and is now in retention. The roentgenogram was taken one month after completion of treatment. Note the wide lamina dura on the distal surface of the alveolus and the trabecular arrangement of the supporting spongiosa. A new lamina dura is being formed on the mesial aspect of the alveolus as a result of new bone formation on that surface.

The time and stage of tooth movement is therefore important in the analysis of the lamina dura. In all cases, a prominent lamina dura indicates an area of new bone formation. However, the direction of movement is indicated only during active tooth movement.

From the preceding, it can be seen that careful analysis of a good roentgenogram can reveal a great deal to the clinician. A good intraoral roentgenogram is to the clinician what a good histologic section is to the experimenter. Both deserve careful study.

DISCUSSION

Histophysiologic Correlations.—Examination was made in histologic sections of areas corresponding to the lamina dura in the roentgenogram in a manner similar to that described by Becks and Grimm.[8] Such study showed that the lamina dura is actually the alveolar bone proper (inner compacta cribriform plate) of the alveolar process. Histologically, the lamina dura was the newly formed and calcified layer of bone immediately adjacent to the periodontal membrane.

The histologic characteristics of the lamina dura were best seen in sections of teeth that had been moved as a result of eruption, mesial drifting, or orthodontic treatment. Histologic analysis showed that the newly formed bone on the periodontal surface of the alveolar bone proper, which is deposited during tooth eruption,[7] mesial drift,[6] and orthodontic tooth movement[3] is fibrous in nature. This fibrous bone soon becomes reorganized into lamellar bone. The newly formed fibrous bone appears thick and radiopaque in the roentgenogram. When it is reorganized into lamellar bone, the roentgenogram shows it to be thinner and much less radiopaque.

Radiopaque Borders in Other Bones.—While one can only speculate as to the reason why the newly calcified alveolar bone is more radiopaque than the older adjacent bone, this phenomenon is not peculiar alone to the bone surrounding the tooth. A similar phenomenon is observed in the growing inner table of the bones of the cranial vault, the growing margins of the cranial sutures, and the growing epiphyses of the long bones. These sites of active bone deposition appear distinctly radiopaque and also have been described as "lamina dura."[1] Newly calcified bone is radiopaque in any part of the body that can be observed radiographically.

SUMMARY AND CONCLUSIONS

One thousand full-mouth intraoral roentgenograms of patients from 2 to 50 years of age were examined to analyze the changes in the lamina dura during and after the eruption of the teeth. Two hundred sets of roentgenograms were of patients undergoing orthodontic treatment. In addition, sixteen jaw specimens ranging from birth to old age were analyzed roentgenographically and in histologic sections. The following conclusions were drawn:

1. The character of the lamina dura was found to be directly related to the stage and rate of eruption of the tooth it surrounds. The lamina dura was thicker and characteristically radiopaque (and the periodontal space was wider) during the active eruption of the tooth. The lamina dura of the roentgenogram corresponded exactly to the actively growing alveolar bone proper seen in the histologic section.

2. The thickness and radiopacity of the lamina dura (and the width of the periodontal membrane) diminished rapidly after the tooth achieved full occlusal contact and active eruption ceased. The rate of new bone formation also diminished markedly. However, the lamina dura remained visible in the roentgenograms as a continuous, but narrow and only moderately radiopaque, band around the periodontal membrane as long as the tooth was in function. This was correlated with the fact that a moderate amount of new bone formation occurs on the alveolar bone proper throughout life.

3. During orthodontic tooth movements, the lamina dura became much thicker and more radiopaque (and the periodontal membrane became wider) on the side of tension and new bone formation. On the side of pressure the lamina dura became thinned, irregular, and finally disappeared as a result of resorption. After the completion of the tooth movement and during the

period of retention, a new lamina dura appeared on this resorbed surface as a result of the formation of new bone.

4. The roentgenogram is the clinician's microscope. The thickness and degree of radiopacity of the lamina dura in the roentgenogram indicate the area and amount of new bone formation and, therefore, also the direction and amount of tooth movement.

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808 South Wood St.

STONE AGE MAN'S DENTITION

With Reference to Anatomically Correct Occlusion, the Etiology of Malocclusion, and a Technique for Its Treatment

P. R. Begg, D.D.Sc. (Adel.), L.D.S. (Vic.), B.D.Sc. (Melb.), Adelaide, South Australia

(Continued from the April issue, page 298.)

Some evidence from tooth anatomy and physiology will now be given to show that the evolutionary development of anatomically correct (attritional) occlusion, both phylogenetically and ontogenetically, is entirely dependent on the occurrence of continual tooth attrition.

DEPOSITION OF SECONDARY DENTINE

The process of deposition of secondary dentine by the pulp evolved to prevent pulp exposure by tooth wear, and not to wall off dental caries from exposing the tooth pulp.

Dental caries is almost nonexistent in Stone Age man, but throughout practically all the time after tooth eruption marked attrition was never absent from all his teeth. In old age, however, the process of deposition of secondary dentine sometimes failed to proceed as fast as tooth wear, so that exposure and death of the pulp ensued. Dental caries soon occurred in these exposed pulp chambers and periapical abscesses developed.

Secondary dentine is laid down in civilized man when there is no attrition or caries, so that in old age the pulp chamber is often almost, and sometimes quite, obliterated. This indicates that we still retain the hereditary process of secondary dentine deposition, although this process evolved in response to a condition which no longer exists.

THE PROCESS OF CONTINUAL TOOTH ERUPTION

B. Gottlieb[4] seems to have been the first to draw attention to this process in man, but, as he did not have experience with the extent of tooth attrition in primitive man, he could not find why it occurred.

However, against adverse criticism and without proof to support his idea, he insisted that continual tooth eruption is a normal physiologic, and not a pathologic, process.

In 1938, I showed that continual tooth eruption evolved, in its present form, to compensate for tooth attrition in our ancestors.[5]

THE PROCESS OF CONTINUAL MESIAL MIGRATION OF THE TEETH

This process, as has already been mentioned, has evolved to preserve the continuity of the dental arches by proximal contact of the teeth, as the teeth wear away interproximally, and to prevent the development of less efficient dental arches with spaces between the teeth.

THE SHAPES AND FORMS OF THE CROWNS OF THE TEETH

In order to withstand rapid attrition, both occlusally and interproximally, the teeth evolved to their present anatomic shapes and forms so that the greatest amount of enamel and dentine covering the pulp was on the occlusal, incisal, mesial, and distal surfaces, whereas, on the lingual, buccal, and labial surfaces, which are not subject to attrition, the teeth are relatively thin from tooth surface to pulp.

For reasons to be considered later, the buccal cusps and part of the buccal surface of the lower sixth year molar and the lingual cusps of the upper sixth year molar also have a great thickness of enamel and dentine.

MESIODISTAL WIDTHS OF THE DECIDUOUS MOLARS

If the total mesiodistal lengths of the deciduous molars were not greater than these lengths of the premolars, interproximal attrition would have reduced Stone Age man's deciduous molars so much mesiodistally that there would have been insufficient space mesiodistally for the eruption of the premolars. Attrition would have caused malocclusion in Stone Age man but for this evolutionary adaptive allowance.

SMALL MESIODISTAL DIAMETERS OF THE TOOTH NECKS AND ROOTS AND TAPERING ROOTS

As attrition eliminates the tooth crowns to their necks, mesial migration brings the teeth into, or very close to, actual interproximal contact.

Therefore, if tooth roots were as wide, or nearly as wide, mesiodistally as the crowns, and if the roots did not taper, the unerupted parts of the roots of neighboring teeth would be so close together in their sockets that the bony alveolar septa and the periodontal membranes would be resorbed interdentally. The teeth, thus without support, no doubt would be useless for mastication and prone to pathologic conditions of the roots and their investing structures.

CONTINUAL TOOTH ERUPTION; THE PROCESS OF OCCLUSAL AND MESIAL TOOTH MIGRATION

Tooth enamel is apparently the hardest substance which zoological protoplasm can produce and has evolved to withstand frictional wear.

In evolving hardness, plasticity has been lost. Therefore, for the survival of the dental apparatus, the loss of plasticity of tooth substance has been compensated for by the evolving of marked plasticity of tooth-investing alveolar bone and periodontal membrane. Consequently, in the dental apparatus there are two bony substances alongside each other which, in an important respect,

are dissimilar. One substance, tooth enamel, is the most unalterable, rigid, and nonplastic and the other substance, alveolar bone, is the most plastic of all the bones in the body. The juxtaposition of these opposites in degree of plasticity was necessary for the evolutionary development of the highly specialized dental apparatus.

Enamel, inert because it has lost its formative organ, cannot move of its own accord to keep the dental apparatus efficient as the enamel wears. Enamel has lost its mobility, and this is compensated for by the plastic alveolar bone and periodontal membrane. The mechanism for supplying this mobility is the process of occlusal and mesial tooth migration, that is, continual tooth eruption.

Orthodontic treatment is made possible by exploiting the mechanism which permits the migratory tooth movement described previously.

Alveolar bone evolved its extreme plasticity to supply mobility to tooth enamel, as enamel cannot itself move to compensate for attrition.

PULPAL PAIN

In dental literature it is accepted that the main reason for the pulp having the power to feel pain is to warn that teeth have become carious. However, the pain warning is too late, since, when teeth are so carious that they are painful, caries has often approached too closely to the pulp for prevention by artificial means of pulpal death.

In Stone Age man, caries was almost nonexistent except in old age, but attrition was always present. If, in Stone Age man, caries on rare occasions caused pulpal pain, nothing could be done to prevent the death of the pulp, so the warning had no survival value.

Pulpal pain did not evolve to warn of dental caries, but to warn that attrition was approaching the pulp faster than secondary dentine was being laid down. The value of this pain warning was that it caused automatic avoidance of chewing on those teeth which were most worn and transference of the chewing to another part of the mouth until secondary dentine deposition could overtake the attrition, thus protecting the pulp from exposure. This transference of the site of chewing has been observed in sheep living on a hard diet in drought country.

The ability to feel pulpal pain evolved chiefly to protect the vitality of the pulp from encroachment of attrition.

TUBERCLE OF CARABELLI

The tubercle of Carabelli is a tooth cusp often, but not always, present on the lingual surface of the upper molars. When present, it is always largest on the sixth year molars. It is often quite large, but seldom, if ever, as far as I know, extends far enough occlusally to reach the level of the occluding surface of the tooth in the absence of attrition. Therefore, the tubercle does not occlude with the lower sixth year molar. Because of its failure to occlude, this tubercle or extra cusp is regarded as a vestigial remnant that has no function.

Odontologists have endeavored to trace its evolutionary origin, but available literature suggests that all agree it has had no function in man. However, as will now be shown, this tubercle has played an important part in the evolution of masticatory efficiency of the dental apparatus up until the relatively short evolutionary time since man has been civilized.

As attrition progressed in primitive man, it was not long before this tubercle occluded with the lower antagonizing tooth and played a vital part in mastication and in the prevention of damage to the dental apparatus.

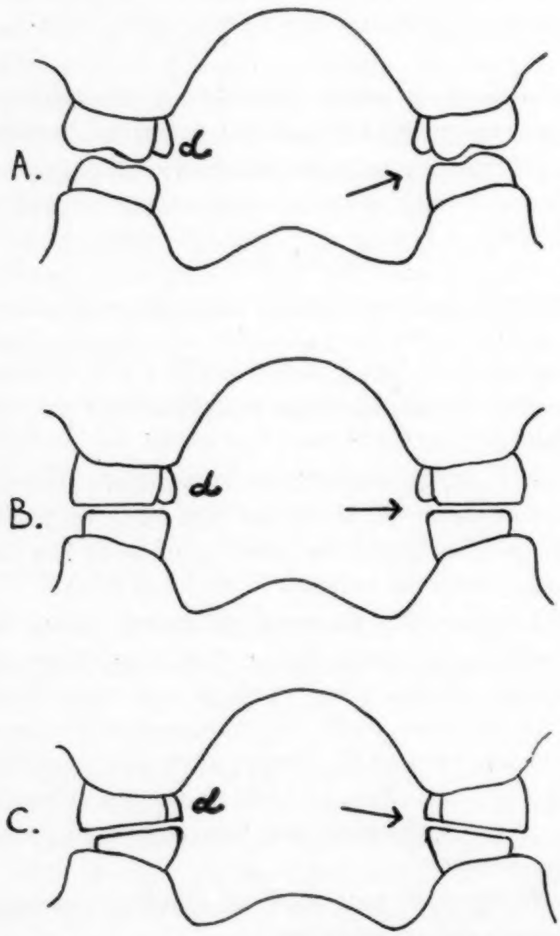

Fig. 4.—To show that, in Stone Age man, the tubercle of Carabelli always came into occlusion. See text for functional and evolutionary significance of this tubercle.

T. D. Campbell[6] described the changes buccolingually of the angle of the occlusal plane which were brought about by occlusal attrition in the molar region. If Campbell had not previously made this important discovery, I would not subsequently have discovered the cause of the existence of the tubercle of Carabelli.

This tubercle is very rare in Australian aborigines, but it was often present in early European man.

I have observed in Stone Age man that, when the upper and lower sixth year molars erupt and their then unworn cusps lock in occlusion, the buccolingual plane of occlusion is oblique, with the level of this plane higher buccally and lower lingually, just as it is in textbook normal occlusion.

Soon, as occlusal attrition commences, the lingual cusps of the upper molar and the buccal cusps of the lower molar wear at a faster rate than the buccal cusps of the upper molar and the lingual cusps of the lower molar. Therefore, the transverse occlusal plane gradually loses its obliquity and becomes horizontal (Fig. 4, *A*, *B*, and *C*).

As attrition becomes more marked, the plane of occlusion in the sixth year molar region assumes an opposite angle of obliquity to its original angle. As a result of this change of the angle of the transverse plane of occlusion in Stone Age man, the lower sixth year molar slides lingually and the upper sixth year molar slides buccally along the inclined plane of occlusion so that, in centric occlusion, the lower molar occludes with the tubercle of Carabelli.

This tubercle, instead of being useless, was very important for man because it came into occlusion in Stone Age man and compensated for the attritional reduction of area of occlusal contact by providing more occlusal surface for mastication on the sixth year molars.

THE VARIATIONS OF LENGTHS OF UNWORN TOOTH CROWNS, OCCLUSOCERVICALLY, IN RELATION TO ATTRITION AND TO TIMES OF TOOTH ERUPTION

Further evidence that the evolutionary development of the forms, sizes, and shapes of unworn teeth is inextricably interwoven and determined by adaptation to resist attrition may be deduced by comparing the long axis lengths of the crowns of teeth of different denominations.

The occlusocervical length of the crown of the first permanent molar is greater than that of the second permanent molar in order to resist attrition for the six years that this molar is already in occlusion before the eruption of the second molar.

For a similar reason, the crown length of the third molar is even less than that of the second molar.

Likewise, and for a similar reason, the second premolar is shorter occlusocervically than the first premolar. The lateral incisors are also shorter than the central incisors. The canines are unique in that they, erupting later than their neighbors, have relatively longer crowns. But this is not contradictory to the general rule that the teeth that are the earlier to erupt have the longer crowns, as the rate of eruption of the canines is of necessity faster than for the other teeth. The canines are farther from the ultimate positions they will occupy on occlusion while they are developing in their embryologic positions in the jaws, and therefore they have a greater distance to travel to the line of occlusion. Their corner positions in the dental arches also expose them to more qualitative and quantitative function than their neighbors.

In dried Australian aboriginal skulls, especially those which have been buried in red earth, the level of attachment of the periodontal membrane

from the teeth can often be seen. Also, the stains show the level of the free gum margin so that the height of the gingival trough can be determined. Fig. 5, *A* diagrammatically shows the level of attachment of the periodontal membrane to each tooth in adult civilized man.

Attrition of the teeth, shown in Fig. 2, is so marked that most of the tooth crowns have disappeared.

For the distance from the occlusal surface to the level of periodontal attachment to vary to such an extent from tooth to tooth as it does in civilized man is an anatomic abnormality and contributes, as will be shown later, to the development of pyorrhea. However, in Stone Age man, the distance from the worn occlusal plane to the level of periodontal attachment is almost the same throughout life for each tooth (Fig. 5, *B*), and this anatomically and physiologically correct condition is due to attrition and is still further evidence that Stone Age man's attritional occlusion is the anatomically correct occlusion for man.

A.

B.

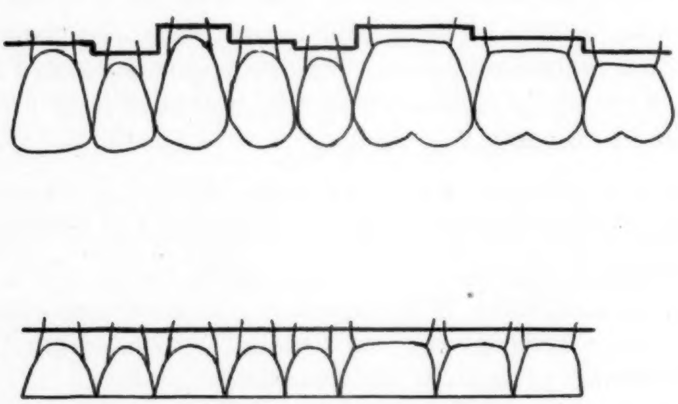

Fig. 5.—To show that, in civilized man, *A*, the level of periodontal membrane attachment to the teeth differs for each tooth; whereas, in Stone Age man, *B*, this attachment level is on the same horizontal plane for all the teeth.

THE ETIOLOGY OF PYORRHEA IN RELATION TO STONE AGE AND CIVILIZED MAN'S OCCLUSION

Absence of pyorrhea in Stone Age man and its almost universal presence, to some degree, in civilized adults are contributory evidence that the occlusion of the former is correct and that the latter's textbook normal occlusion is an abnormality (Fig. 7).

The following is an explanation of the cause of pyorrhea.

In civilized man, the teeth are not worn away as fast as they continually erupt. Therefore, the distance from the occlusal surface to the level of attachment of the soft tissues to the tooth becomes continually greater, so that the gums receive less and less friction from the food that slides down buccally and lingually from the occlusal surfaces of the teeth. As age advances, civilized man chews higher and higher up on stilts because of continual tooth eruption. Gum grows continuously throughout life to replace loss from friction and, unless it is rubbed sufficiently by hard food, the gum remains soft

and spongy instead of becoming hard, firm, and keratinized. Gum also overgrows in the absence of sufficient frictional wear so that the gingival trough is deepened and the distance from the free gum margin to the level of gum attachment to the tooth increases. Buccally, labially, and lingually, the gum is prone to bacterial invasion on the free gum margin and in the gingival trough, as its surface, being soft and nonkeratinized, is easily broken so that bacteria can gain entrance.

Following is an account of the development of pyorrhea interproximally.

As there is practically no interproximal tooth attrition in civilized man, there is a triangular interproximal space between neighboring teeth (Fig. 7). The base of this triangle is at the level of attachment of the gum to the teeth. The two sides are formed by the proximal surfaces of neighboring teeth and its apex is at the contact point. In this space, the gum is attached only at the two ends of the base of the triangle and the gum filling the space is free of attachment to the walls of the teeth.

This interproximal gum tissue usually fills the interproximal space right from the base to the apex of the triangle. As continual tooth eruption proceeds, the base and two sides of this triangle continually lengthen throughout life. Therefore, in the interproximal space the two gingival troughs continually deepen with age. The walls of the teeth prevent the food from supplying friction by massage to this interproximal gum. Therefore, in this continually enlarging interproximal stagnation region, ever-worsening pyorrhea develops through bacterial action.

This description of the etiology of pyorrhea seems to account adequately for the known phenomena of this disease.

The description that follows explains why pyorrhea is hardly ever present in Stone Age man and at the same time gives further evidence to support the theory of its etiology that has just been given.

In Stone Age man, continual occlusal attrition wears down the teeth as fast as they continually erupt, so that the distance from the occlusal surface to the continually receding level of gum attachment is constant under these favorable circumstances. This distance is always so small that the hard, coarse, fibrous, gritty food is pressed over the occlusal edges of the teeth during chewing and then strikes the gums so that it massages them labially, buccally, and lingually. Therefore, the gums surrounding the teeth in these positions are kept hardened and keratinized. They are also prevented from overgrowing by this food massage, so that a deep gingival trough cannot form. Therefore, bacteria cannot invade this labial, buccal, and lingual gum tissue, so pyorrhea does not develop in these positions.

The following account explains the absence of pyorrhea in the interproximal spaces in Stone Age man.

Due to continual interproximal attrition and to the maintenance of contact of neighboring teeth in Stone Age man, the triangular interproximal space

just described does not enlarge continually, but remains very small throughout life. Therefore, there is insufficient space in this triangular region for an ever-enlarging mass of soft gum tissue.

The level of attachment of the gum interproximally is close enough to the place where neighboring teeth come into contact that the gingival trough is so shallow it is sometimes almost nonexistent.

Because of the great width buccolingually of the contact surfaces of neighboring teeth which are undergoing the process of attrition, the interproximal embrasures are so shallow that any gum tissue occupying these embrasures receives adequate massage from the food. Therefore, interproximally, Stone Age man is free from pyorrhea.

However, in Stone Age man a few older individuals show evidence of stagnation areas of pyorrhea buccally along the gum margins of the upper sixth year molars because of the sliding buccally of the upper molars, as previously referred to in connection with the change in the angle of the plane of occlusion buccolingually.

From the foregoing, it is obvious why presence of pyorrhea is the rule for civilized man and absence of pyorrhea is the rule for Stone Age man.

From the etiology of pyorrhea we see the reason why tooth grinding, paraffin packing, gingivectomy, and drugs will not permanently cure the disease.

Artificial tooth grinding, if it could be carried out with sufficient skill every day (both occlusally and interproximally, even to the fourth stage of Broca), would not cure pyorrhea unless food similar to that of Stone Age man were always eaten to keratinize the gums, or unless the equivalent daily artificial massage were supplied.

The following variables affecting the process of pyorrhea must be taken into account, as they are significant in relation to the description just presented of the cause of this disease: variations in the susceptibility and resistance to bacterial infection; variations in the amount, speed, and evenness around the teeth of continual tooth eruption; variations in the sizes and anatomy of the teeth; variations in food habits; variations in gum as regards its response to friction by hardening and atrophy.

In an article on orthodontics, reference to pyorrhea and to treatment is justified because neither textbook normal occlusion nor anatomically correct attritional occlusion can be presented in true perspective without referring to it.

OCCLUSAL, INTERPROXIMAL, AND GINGIVAL MARGINAL DENTAL CARIES

G. V. Black long ago pointed out that the positions on the teeth that are most prone to caries are the food retention areas of the occlusal grooves, pits, and fissures; the proximal surfaces; and at the gingival margins.

However, in Stone Age man these three regions of the teeth are far from being stagnation areas, but are continually agitated by the hard, coarse, fibrous, gritty food so that carbohydrate food is not retained long enough for

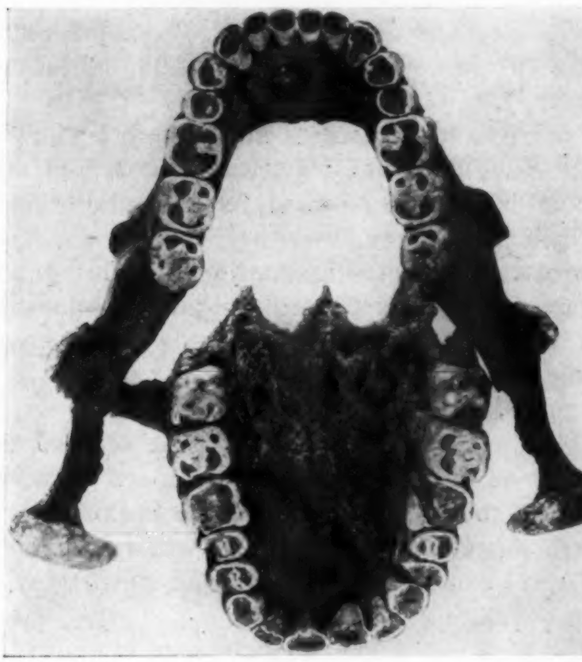

Fig. 6.—Attrition of the teeth in an Australian aboriginal. The tubercles of Carabelli, at the mesiolingual angles of the upper first permanent molars, are well worn, due to occlusal contact with the lower teeth.

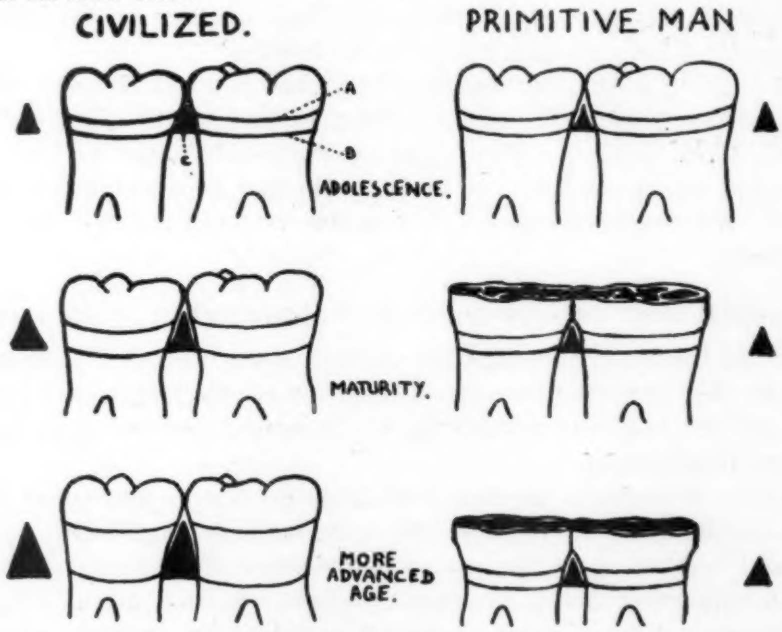

Fig. 7.—Diagrammatic comparison of the changes at different ages of the teeth and gums of primitive man and civilized man to show how primitive man remained free from pyorrhea because the gingival gum trough, $A \leftrightarrow B$, was kept too shallow by the friction from his crude food to harbor bacteria. The interproximal space was kept small by interproximal attrition. Civilized man develops progressively worse pyorrhea as he gets older, because insufficient friction from his food allows development of gingival troughs so deep, due to gum overgrowth, that bacteria can lodge in them. Also, in civilized man, lack of interproximal attrition allows the growth of a progressively larger interproximal gum papilla in the interproximal space which becomes progressively larger as the gum is detached from the tooth surface. The triangles represent the relative sizes at different ages of the interproximal space. *A*, Free gum margin; *B*, level of soft tissue attachment to tooth; *C*, interproximal gum papilla; $A \leftrightarrow B$, height of gingival trough. (From Begg, P. R., AM. J. ORTHODONTICS AND ORAL SURG., October, 1945.)

acid fermentation to produce dental caries. The tooth attrition, occlusally and interproximally, gives a good indication of the agitation on these tooth surfaces (Figs. 6 and 7).

The teeth at the free gum margins in Stone Age man are also not food stagnation areas, as, due to occlusal attrition, these gum margin regions of the teeth throughout life are so relatively close to the occlusal surfaces that they are agitated by food massage.

Also, because of continual tooth eruption, the free gum margin recedes further rootward on the tooth surface as the gum is kept worn down by food massage so that a new part of the tooth surface is always becoming the region at the free gum margin.

Caries is common in civilized man because, due to soft food and to the resultant abnormal absence of tooth attrition, the occlusal tooth surfaces retain their deep grooves, pits, and fissures which act as food retention areas. Also, in civilized man the erupted parts of the proximal tooth surfaces, becoming always larger because of continual tooth eruption gingivally to the contact points, are not continually agitated and worn away as in Stone Age man, so that caries develops interproximally.

Again, the free gum margin in civilized man, owing to insufficient food friction, does not recede at the same rate as the teeth continually erupt, but the gingival trough deepens with age. As the level of civilized man's free gum margin recedes very little throughout life, food remains on this one part of the tooth surface long enough for caries to develop.

I met a young Australian aboriginal who had just left his tribe, which then lived on a Stone Age diet. At that time, he had neither dental caries nor pyorrhea. After living for four years on white man's diet he had extensive pyorrhea and caries, and several of his teeth had been extracted because of toothache. His dental degeneration was due to cessation of frictional tooth and gum wear.

EVOLUTIONARY CHANGES IN THE BONY ARCHITECTURE OF THE FACE

In an anthropometric study, Sir Arthur Keith and C. C. Campion[7] concluded that since ancient Saxon times bony evolutionary changes have brought about a relative vertical lengthening and a lateral narrowing of the face of the modern Englishman.

However, it seems to me that these changes can be accounted for by the fact that continual tooth eruption makes the modern Englishman's jaws move further and further apart because of the absence of occlusal attrition of the teeth. On the other hand, continual occlusal attrition allowed the ancient Saxon's upper and lower jaws to remain about the same distance apart throughout life, just as Fig. 2 shows to have occurred in the Australian aborigine.

If Keith and Campion had taken continual tooth attrition and continual tooth eruption into account, they would not have concluded that evolutionary anatomic changes in the jawbones account for the difference between the broad face of the ancient Saxon and the long face of his descendant, the modern Englishman.

It may be mentioned here that although many writers claim that when ideal conditions of so-called textbook normal occlusion prevail, the jaws, being therefore anatomically correct, make masticatory excursions in the perfect manner. However, with the retention of tooth cusps, perfect functioning of the dental apparatus is impossible. Again, with continual tooth eruption, the lengthening of the teeth causes the vertical distance between the jaws to become progressively greater, and thus more and more anatomically abnormal.

Therefore, in the absence of marked tooth attrition, the masticatory excursions of the mandible of civilized man can never be ideally correct.

(This article will be continued in future issues of the Journal. References will appear at the end of the article.)

Editorial

A Panel Discussion of Orthodontics

A PANEL discussion on the subject of orthodontics was held before the St. Louis Dental Society on Feb. 1, 1954, at a regular monthly meeting, on the occasion of National Children's Dental Health Day. The panel consisted of the following instructors from the orthodontics departments of two dental schools: Fred Fabric, D.D.S., L. B. Lundergaan, D.D.S., Peter Sotiropoulos, D.D.S., and K. C. Marshall, D.D.S. The moderator was Carl W. Lattner, D.D.S., an oral surgeon.

One of the schools represented was Washington University, the other was St. Louis University (formerly Marion Sims Dental College), which was the first dental school in the world to create a special orthodontics department. Under the direction of Dr. Edward H. Angle, known as the "father of orthodontics," the school's orthodontics department was organized around the beginning of this century.

The procedure was to pose questions, directed to alternate members of the panel, for major discussion, after which supplementary comment was supplied by the remaining panelists.

The program proceeded as follows:

When Should Treatment of Anterior Cross-Bite Be Instituted?

MAJOR COMMENT:

As soon as possible.

If the mandible can be retruded so as to bring the anterior teeth in edge-to-edge relationship, there is a good chance for successful treatment.

METHODS OF TREATMENT:

Tongue blade exercise.

Lower anterior acrylic splint.

Lower Hawley type appliance with incisal incline.

ADDED COMMENT:

1. (a) In the deciduous dentition, cooperation of the patient is most important. Therefore, treatment should be instituted when this is possible.
   (b) In employing the tongue blade, the parent's cooperation is most important.
2. A clothespin may be substituted for the tongue blade.

When Should Treatment of Posterior Cross-Bite Be Instituted?

MAJOR COMMENT:

As soon as it is seen.

Cross elastics should be employed in molar areas.

If corrected in the primary dentition, early, the permanent dentition may be corrected.

It is to be remembered that the lateral growth of the arch depends upon elimination of the cross-bite.

Always make the parent understand that treatment of the permanent dentition may be necessary later.

Check on leaning habits.

ADDED COMMENT:

1. The correction of posterior cross-bite at an early age does not necessarily correct the permanent dentition erupting later.
2. If the cross-bite is bilateral, correct it very early, as the maxilla is slightly accelerated in growth compared to the mandible.
3. Midline shift may occur due to occlusal interference of cross-bites.

When Should Maxillary Protrusions Be Corrected?

MAJOR COMMENT:

It is impossible to determine the time chronologically. The dental age is the prime factor.

Use short duration treatment *only* in the primary dentition.

Always remove the etiological factors first, as habits, or environmental.

There may be poor muscular balance. Myofunctional therapy may be advisable.

When there is danger from trauma to anterior teeth.

When the child is a victim of ugly remarks.

ADDED COMMENT:

1. Bear in mind that the ultimate treatment cannot be reached in early treatment. It is best to treat in two stages.

When Are Space Maintainers Indicated?

MAJOR COMMENT:

It should be remembered that space maintenance is the best preventive orthodontics.

The older techniques for space maintainers were too complicated. Employ the new, simple techniques.

Actually, the new pulpotomy techniques render using primary teeth fit for retention. Hence, they are splendid space maintainers.

In good recall risks, it is good to measure and record the spaces left by prematurely lost primary teeth.

It is not as important to retain the space left by an extracted first primary molar as that left by a second primary molar.

If mandibular primary canines are lost prematurely due to anterior crowding, a fixed lingual arch is a good retainer. Its important function is to keep the molars from moving mesially.

Anterior space maintainers are not necessary, especially across the midline. Use small dentures to replace lost anterior teeth for esthetics.

When Should Primary Teeth Be Retained?

MAJOR COMMENT:

When any portion of the erupting permanent tooth is visible, the primary tooth is considered in prolonged retention.

Compare both sides of the arch. If a permanent tooth has erupted on one side, extract the retainer primary tooth in the corresponding area on the opposite side and remove any overhanging bone.

ADDED COMMENT:

1. There may be instances in which the spaces should be allowed to close as in cases of congenitally missing teeth.
2. (a) Always prevent tipping of permanent molars.
   (b) Do not worry as much about the loss of first primary molars, as the second primary molars may be disked to allow for eruption of premolars.

Should the Superior Labial Frenum Be Excised and, If So, When?

MAJOR COMMENT:

A *truly* enlarged frenum must be excised; some will atrophy.

Watch as the permanent incisors erupt. It may persist until eruption of the permanent canine.

Watch for tongue and lip habits. They, not the frenum, may be causing spacings.

If frenectomy is resorted to, it may be best to use an appliance immediately so as to not be impeded by scar tissue.

ADDED COMMENT:

1. (a) Watch for hereditary factors. If the teeth remain upright, chances are such factors are present.
   (b) Always advise surgical removal, not clipping.

Should Thumb-Sucking Be Stopped and, If So, When?

MAJOR COMMENT:

This subject is highly controversial. All dentists, but not all pediatricians, think it should be stopped.

The time for interception may be as follows.

(a) Early (up to 1 year)—close sleeves of night clothes.

(b) Use of solutions painted on thumb.
(c) After 4 years—construct a lingual arch appliance, destroying suction. Do *not* use stickers.

In addition, talk to the child and explain what the habit may cause.

ADDED COMMENT:

Always remove the parent while talking to the child.

Tell the parent not to heckle the child, but to ignore the habit.

It is believed that the pediatricians are coming over to the dentists' viewpoint.

Should Primary Submerged Molars Be Removed and, If So, When?

MAJOR COMMENT:

Extract under the following circumstances.

1. When gingiva is chronically inflamed.
2. When exfoliation is interfered with.
3. When root structure is bad.
4. When stresses of mastication seem too great.
5. When these teeth are deflected out of alignment.

Retain when the roots are normal and may be crowned.

What Should Be Done in Cases of Congenital Absence of Second Premolars?

MAJOR COMMENT:

In cases of severe irregularities of incisors, extract the primary molar.

If everything seems normal, or can be made so, keep the primary molar.

Should Primary Teeth Be Removed to Make Room for the Eruption of Permanent Teeth?

MAJOR COMMENT:

"Do this, but carefully, and watch!

Editorial Comment.—The publication of this material is thought to be of importance, as it is a report of the answers which authorities (teachers) are giving to the profession.

E. E. S.

Correspondence

Editor's Comment

The editorial entitled "Protect Yourself and Your Interests" [Am. J. Orthodontics, December, 1953] has attracted so much attention that further inquiry by the editor to the author, Dr. C. F. Stenson Dillon, has brought forth the following letter. It is believed this letter will be of interest to the readers of the American Journal of Orthodontics.

To the Editor:

There has been considerable agitation in this area, and some from other components, to the effect that reprints of my editorial, to which you refer, should be sent to all the members of the American Association of Orthodontics. Your plan, expressed in your letter of Jan. 8, 1953, will relieve me of the effort and responsibility of attending to this task personally. I hope you will be successful.

You asked, "Is it not true that much of the trouble in settling estates of deceased members of the Pacific Coast Society of Orthodontists came from the fact that patients suddenly found themselves with no one to continue treatment?" The answer to this question requires a bit of elaboration. In the first place, the condition of the estates left by deceased orthodontists has not been peculiar to any component society or geographic area included in the American Association of Orthodontists. I made a point of investigating conditions in all parts of the United States and found that the situation as presented here in the West was duplicated in all areas.

The answer to your question is a qualified "yes." Many of the difficulties encountered were the result of patients' being "set free" without provision having been made for continued or subsequent treatment. This gave rise to much unpleasantness and the filing of claims by patients for recovery of funds or demands that adequate treatment be provided for the unfinished cases. It is true, also, that many, or most, orthodontists are reluctant to assume responsibility for cases just begun, partially treated, or giving evidence that successful completion is improbable. The problem of different appliance technique makes itself known, also. In this latter instance, there is little that can be done to influence a man to attempt treatment with an appliance in which he is not trained, in which he has no faith, or which he considers inadequate. However, much can be done to alleviate this situation. It long has been my opinion, in which I find myself unsupported, that every component of the American Association of Orthodontists should maintain, for every member, complete files indicating the type of appliance with which he is familiar, uses, or is teaching in an accepted school of dentistry. In the event of a death in the membership, the secretary could be contacted to learn which men in that area are trained in the appliance used by the deceased. The patients then can be funneled through these offices without causing the friction and embarrassment so frequently encountered when a patient under treatment is left to select an orthodontist or is referred indiscriminately. Some of us are skilled in only one type of appliance or treatment method. Others are capable of handling, and are familiar with, several. These skills should be on file. Personally, I use three accepted methods in my own practice: two are full-banded techniques, and the third requires partial banding. All three methods would be confusing to a confirmed labiolingual man. I cite this merely as an instance where unpleasantness could result if my patients were left to shift for themselves. In the same manner, if labiolingual or removable appliance patients were sent to me, I would be embarrassed and would have to seek another reference for these children. Hence, my recommendation that a file be kept of all orthodontists and their preference of treatment methods.

Much confusion and unpleasantness could be avoided if all orthodontists would keep adequate patient records of what is being done, what appliance is being used, what is anticipated, and when different operations were performed. It should be possible for any capable orthodontist to consult the records of another and learn, without extrasensory abilities, exactly what method of treatment is being used on each case, to what extent the potential appliance has been completed, when bands were cemented or recemented, and what has been accomplished. With records of this kind, it is easy for a friend or a member of the Necrology Committee to direct patients into proper channels, rather than send them where they will be unwanted or unaccepted, or where, in order to have treatment continued, they will need reappliancing.

Another factor in the creation of claims and litigation against estates comes from the practice of accepting orthodontic cases upon a contracted or agreed-upon cost-to-completion amount. I firmly believe that this widespread practice is a detriment to orthodontics and assumes the dimensions of selling orthodontic service by the package. In the event of the death of an orthodontist whose practice is managed on this designated fee-to-completion schedule, there are, of necessity, many uncompleted cases for which the total fee has been paid. There are other cases that are more nearly paid out than completed, and there are those for which an appreciable sum has been paid with no apparent results. This is unvoidable under this method. The assuming orthodontist cannot be criticized for his reluctance to accept burdens of practice with no, or at best noncommensurate, recompense. This particular evil easily can be abrogated and has been done in my office and the offices of others with whom I am acquainted. An elastic fee, consisting of an initial payment (not a "down payment") at the time the case is started, followed by consecutive monthly payments agreed upon (not installments on principal obligation) until the case is completed leaves the orthodontist with no obligation beyond what has been done. This is a most equitable arrangement from any aspect. The orthodontist is paid only for what he has done, regardless of how much or how little. Upon the termination of his effort, by death or otherwise, there are no patient funds on deposit to be refunded or to induce claims for recovery of monies. In addition, this fee system is more equitable because those cases which respond most readily are completed in the least time, thus costing the patient less than those which drag along for reasons of noncooperation or unknown physiologic factors. Patients in this latter category will pay more, which is as it should be. There is an additional benefit accruing in this method. Cases are finished and dismissed and it costs the patient money as long as he continues to present himself in the office. There is only one disadvantage, and that is the protest by the payer that, "maybe you will drag the case along to get more money." That suspicion is easily destroyed by the simple comment, "If you have that little faith in my integrity, then you have no right to commit your child (yourself) into my care." I know I will meet with violent disagreement on this subject of undeterminate fees. I have been unable to make it popular in my own area, due, I believe, to the long-established custom of the agreed fee-to-completion and the fear that some other orthodontist will accept the patient's demand for a "how much" agreement.

You will note that in entering this discussion of fees I stated that the initial payment is not a "down payment," although it is likely to be interpreted as retirement of part of the principal debt. There is no principal debt in this indeterminate fee method. Also, this initial payment is not described or mentioned as an appliance fee. It is merely paid by the patient or payer as evidence of faith and upon the understanding that the orthodontist has been retained to accept responsibility for the case. Naturally, if the orthodontist should die or become incapacitated before he had earned that sum, he or his estate would be bound morally, not legally, to refund it. However, the initial fee having been paid, the monthly fee payments begin the next month, regardless of how little or how much has been accomplished so that to all intents and purposes the patient and the orthodontist are on equal terms, financially, all through the treatment period. To me this seems a

simple, equitable solution to the fee problem and also to the problem of having unwanted patients casting about from orthodontist to orthodontist trying to find somebody to finish the case for fees, much of which have been paid previously.

You will note that I mentioned the presence of a member of the Necrology Committee in the office of a deceased orthodontist. This, too, has been one of my recommendations for some years and one which, as president of the Pacific Coast Society of Orthodontists, I tried unsuccessfully to have accepted. It seems that the living are obsessed with the idea that they will never die. Death is something that happens only to other people. This is particularly true of the younger men, to whom death is abhorrent and so far in the future that they need have no concern for it. I firmly believe, and I cannot be persuaded otherwise, that the Necrology Committee should be granted infinitely more importance in all our organizations and that it should be activated, supported seriously, and awarded the funds needed to operate in a useful manner. At the death of a member, I believe, and have recommended, that a member of the Necrology Committee, or someone appointed by him, should go to the office of the deceased and assume the burden of practice dissolution. I believe that the men on the committee should be aware of the complexities which might and do arise. I believe that cases of dispute over rightful refunds for work undone or fee estimates for the completion of cases left unfinished by the deceased should be adjudicated by the Necrology Committee. I believe that the members of the American Association of Orthodontists abiding and practicing in that locality should be impressed into accepting these decisions of the committee. The burden thus distributed would not be excessive for anyone and would place orthodontics high in the scale of unselfish public services, a position which, unfortunately, it is not generally granted at the present time. I believe these things without reservation, but with little or no hope of seeing them accepted and acted upon affirmatively.

Further discussion of your question regarding the obstacles encountered in disposing of the practice of a deceased orthodontist inevitably brings up the problem of arranging continuation of treatment. Most of us are aware of the existence of many, many patients upon whose teeth are appliances that cannot be justified by any flexibility of charitable consideration. Cases of this type present a problem without a satisfactory solution. No orthodontist can be condemned or rebuked for refusing to accept the responsibility for the continuation of treatment without reappliancing when the patient presents himself with an indescribable device, conceived in error, executed without skill, and based upon none of the accepted physical and physiologic principles. This is a deplorable situation, which exists and will continue to exist as long as orthodontics is practiced by human beings. Nothing can be done about it.

There is more, much more, to this business of fees, contracts, estates, liabilities, and financial and moral responsibilities, but if I attempted to include it all, this letter would assume the proportions of a thesis or a treatise. I do not believe that is what you had in mind when you asked your question, so I shall not carry this discussion any further.

There is nothing in this letter, nor in any of the information I have accumulated, that you need regard as secret or confidential. Everything within my academic, professional, legal, or general fund of information is at the disposal of every orthodontist to whom it might be helpful. That is my pledge, my privilege, and my pleasure.

I hope you will find some enlightenment in this letter and that you will call upon me for further information or discussion should you see the need.

Best regards,

C. F. Stenson Dillon.

Jan. 20, 1954.

Department of Orthodontic Abstracts and Reviews

Edited by

DR. J. A. SALZMANN, NEW YORK CITY

All communications concerning further information about abstracted material and the acceptance of articles or books for consideration in this department should be addressed to Dr. J. A. Salzmann, 654 Madison Avenue, New York City

A Method of Evaluating Osseous Development From Birth to 14 Years: By Vernette S. Vickers Harding. *Child Development* **23**: 247-271, December, 1952.

In 1930 the Department of Maternal and Child Health of the School of Public Health, Harvard University, initiated a study of the growth and development of a group of well children.

X-ray photographs, of which there are more than 5,000 complete sets or approximately 50,000 films, were examined for pathology by a roentgenologist. The author noted the appearance and development of the bones and their epiphyses. This article gives in detail the findings in regard to the appearance of most of the osseous centers and offers a simple method of rating osseous development in children from birth to 14 years of age.

Fig. 1 shows the centers which are the bases for this method. An osseous center is called present if it is at least 2 mm. in diameter. Exceptions are the epiphyses of the long bones of the hand and foot. These centers often can be seen distinctly when less than 2 mm. in diameter. No twins or prematurely born children are included in the compilation of the osseous centers which appear during the first five years, but data from these two groups of children are included thereafter.

Tables are included to indicate the percentage of children having a particular center at each age. It will be observed that the girls are ahead of the boys in the appearance of the osseous centers. This difference is present at birth, as well as at subsequent ages.

Since orthodontists usually employ the wrist bones, the following has been gleaned from the tables which are included in the original article. Tables III, VIII, and IX are presented in full.

Tables V, VI, and VII show the range for the appearance of certain osseous centers. The middle two columns, which are the twenty-fifth and seventy-fifth percentiles, indicate the ages between which the middle 50 per cent of the children fall. The two outside columns are the tenth and ninetieth percentiles, or are the ages between which 80 per cent of the children are found. If a child is found outside the range of the middle 80 per cent it may be assumed that he is either retarded or advanced.

Tables VIII and IX offer a simple method of estimating osseous development between birth and the age of 14 years. This chart is particularly useful if the same child is to be examined periodically. To use this chart the horizontal column nearest the child's chronological age is selected and all the centers which are present (2 mm. or larger) are underlined. It is advantageous in the ultimate reading of the table if a contrasting color is used. If there is no view of a particular center its name should be crossed out on the chart in order

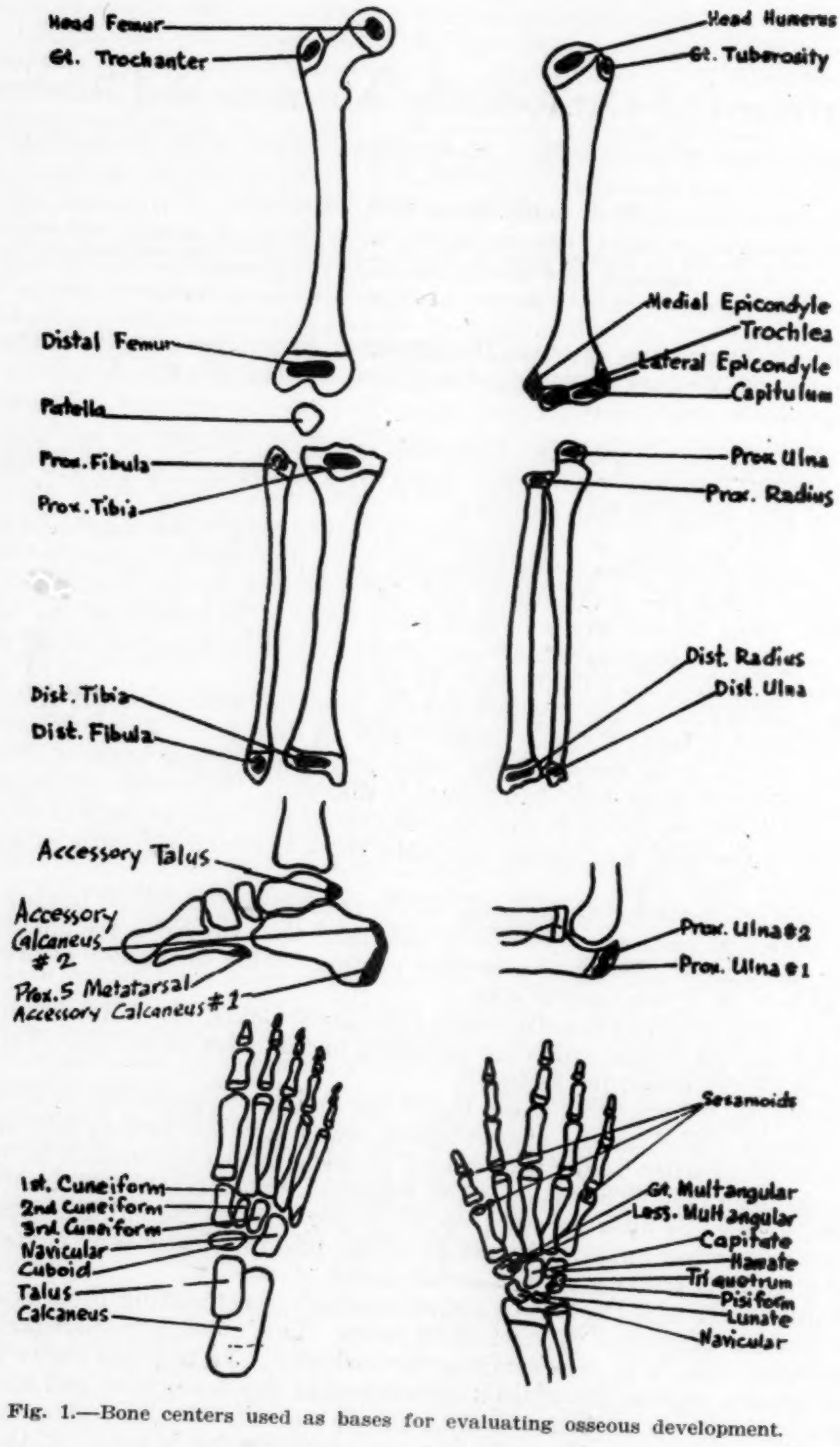

Fig. 1.—Bone centers used as bases for evaluating osseous development.

TABLE I. PERCENTAGE OF OSSEOUS CENTERS IN A GROUP OF BOYS FROM BIRTH TO 14 YEARS (WRIST)

	BIRTH	2 WK.	6 WK.	3 MO.	6 MO.	9 MO.	12 MO.	15 MO.	18 MO.	2 YR.	3 YR.	4 YR.	5 YR.	6 YR.	7 YR.	8 YR.	9 YR.	10 YR.	11 YR.	12 YR.	13 YR.	14 YR.
Capitate	4	10	19	50	94	99	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hamate	5	9	13	38	83	94	96	99	99	100	--	--	--	--	--	--	--	--	--	--	--	--
Dist. Radius	--	--	--	--	4	24	46	72	76	91	98	99	100	--	--	--	--	--	--	--	--	--
Triquetrum	--	--	--	--	8	11	17	21	28	37	65	82	96	99	99	100	--	--	--	--	--	--
Lunate	--	--	--	--	--	--	2	4	4	13	35	55	73	91	97	100	--	--	--	--	--	--
Navicular (hand)	--	--	--	--	--	--	--	--	--	--	1	6	23	50	77	97	100	--	--	--	--	--
Gt. Multangular	--	--	--	--	--	--	--	--	--	--	2	7	24	43	71	87	94	99	100	--	--	--
Less. Multangular	--	--	--	--	--	--	--	--	--	--	2	7	26	48	75	90	100	--	--	--	--	--
Dist. Ulna	--	--	--	--	--	--	--	--	--	--	--	--	1	13	45	75	93	98	100	--	--	--
Pisiform	--	--	--	--	--	--	--	--	--	--	--	--	--	1	2	2	11	24	49	80	97	100
Sesamoid Metac. I (1)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	7	28	56	87
Sesamoid Metac. I (2)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12	25	55
Sesamoid Dist. Metc. V.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9	28
Sesamoid Thumb Interphal.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	17
Fusion																						
Dist. Radius	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
Dist. Ulna	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
No. Cases	136	94	92	114	112	111	121	110	114	112	116	112	108	104	99	94	90	72	63	60	57	48

TABLE II. PERCENTAGE OF OSSEOUS CENTERS IN A GROUP OF GIRLS FROM BIRTH TO 14 YEARS (WRIST)

	BIRTH	2 WK.	6 WK.	3 MO.	6 MO.	9 MO.	12 MO.	15 MO.	18 MO.	2 YR.	3 YR.	4 YR.	5 YR.	6 YR.	7 YR.	8 YR.	9 YR.	10 YR.	11 YR.	12 YR.	13 YR.	14 YR.
Capitate	7	18	33	68	95	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hamate	7	16	28	56	91	99	99	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dist. Fibula	--	--	--	--	9	48	82	97	98	100	--	--	--	--	--	--	--	--	--	--	--	--
Dist. Radius	--	--	--	--	9	42	68	90	93	98	100	--	--	--	--	--	--	--	--	--	--	--
Triquetrum	--	--	--	--	7	15	22	27	30	49	83	97	100	--	--	--	--	--	--	--	--	--
Lunate	--	--	--	--	1	1	3	7	9	23	51	85	94	98	100	--	--	--	--	--	--	--
Navicular (hand)	--	--	--	--	--	--	--	--	--	1	9	39	69	93	100	--	--	--	--	--	--	--
Gt. Multangular	--	--	--	--	--	--	--	--	--	3	17	39	67	91	99	100	--	--	--	--	--	--
Less. Multangular	--	--	--	--	--	--	--	--	--	--	10	33	80	96	100	--	--	--	--	--	--	--
Dist. Ulna	--	--	--	--	--	--	--	--	--	--	--	3	14	52	81	98	100	--	--	--	--	--
Pisiform	--	--	--	--	--	--	--	--	--	--	--	--	--	2	15	38	68	88	99	100	--	--
Sesamoid Metac. I (1)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7	35	68	93	100	--
Sesamoid Metac. I (2)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	5	27	64	92	98
Sesamoid Dist. Metac. V.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8	20	55	80
Sesamoid Thumb Interphal.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8	21	45	71
Fusion																						
Dist. Ulna	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3
Dist. Radius	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
No. Cases	137	99	82	119	121	120	130	119	123	122	122	118	113	106	111	94	86	81	64	56	54	40

TABLE III. PERCENTAGE OF OSSEOUS CENTERS OF THE HAND IN A GROUP OF BOYS AND GIRLS FROM BIRTH TO 14 YEARS

		6 MO.		9 MO.		12 MO.		18 MO.		2 YR.		3 YR.		4 YR.		5 YR.		6 YR.		7 YR.	
		B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G
Metacarpals	1	--	--	--	1	1	8	7	51	25	89	72	100	92	--	98	--	100	--	--	--
	2	1	--	1	12	6	46	47	92	83	100	100	--	--	--	--	--	--	--	--	--
	3	--	--	1	7	6	35	33	84	74	99	95	100	99	--	100	--	--	--	--	--
	4	--	--	--	2	1	18	22	79	58	97	92	100	99	--	100	--	--	--	--	--
	5	--	--	--	1	2	10	14	68	47	94	86	100	98	--	100	--	--	--	--	--
Phalanges Proximal	1	--	--	--	--	--	4	1	36	14	84	63	99	93	100	99	--	100	--	--	--
	2	1	3	5	35	19	75	68	100	93	--	100	--	--	--	--	--	--	--	--	--
	3	1	6	6	44	21	79	76	100	94	--	100	--	--	--	--	--	--	--	--	--
	4	1	5	4	32	13	77	62	99	90	100	100	--	--	--	--	--	--	--	--	--
	5	--	--	2	4	2	27	24	86	63	99	96	100	100	--	--	--	--	--	--	--
Middle	2	--	--	--	2	2	26	14	71	52	97	91	100	100	--	--	--	--	--	--	--
	3	--	2	1	9	3	34	23	80	59	97	93	100	100	--	--	--	--	--	--	--
	4	--	2	--	9	2	38	20	81	57	98	93	100	100	--	--	--	--	--	--	--
	5	--	1	--	2	--	6	2	29	5	66	39	94	70	100	90	--	99	--	100	--
Distal	1	1	6	5	29	11	61	48	93	79	100	98	--	100	--	--	--	--	--	--	--
	2	--	--	--	--	--	2	1	21	4	62	38	97	86	100	96	--	99	--	100	--
	3	--	--	--	2	1	14	6	60	25	89	87	100	99	--	100	--	--	--	--	--
	4	--	--	--	2	--	12	5	54	22	97	85	100	98	--	100	--	--	--	--	--
	5	--	--	--	--		2	1	21	4	61	40	98	84	100	95	--	99	--	100	--

TABLE V. RANGE IN TIME OF APPEARANCE OF OSSEOUS CENTERS OF THE WRIST
(Ages given in years and months except as indicated)

Boys: Range of middle 80 per cent (from)	Boys: 50 per cent (from)	Boys: 50 per cent (to)	Boys: Range of middle 80 per cent (to)		Girls: Range of middle 80 per cent (from)	Girls: 50 per cent (from)	Girls: 50 per cent (to)	Girls: Range of middle 80 per cent (to)
3 wk.	8 wk.	0-5	0-6	Capitate	1 wk.	4 wk.	0-4	0-6
4 wk.	9 wk.	0-6	0-8	Hamate	1 wk.	5 wk.	0-5	0-6
0-7	0-10	1-6	2-0	Dist. Radius	0-7	0-8	1-2	1-4
0-9	1-5	3-7	4-7	Triquetrum	0-7	1-3	2-9	3-6
1-11	2-7	5-1	5-11	Lunate	1-7	2-1	3-8	4-6
4-3	5-1	6-11	7-8	Navicular (hand)	3-1	3-7	5-3	5-10
4-3	5-1	7-3	8-4	Gt. Multangular	2-7	3-6	5-4	6-0
4-3	5-0	7-0	8-0	Less. Multangular	3-1	3-8	4-10	5-8
5-11	6-5	8-0	8-10	Dist. Ulna	4-9	5-3	6-10	7-6
9-0	10-1	11-10	12-7	Pisiform	6-7	7-5	9-5	10-3
11-11	13-1	14-7	15-0	Sesamoid Metac. I. #2	10-3	10-11	12-5	12-11
13-2	13-11	15-6	16-0	Sesamoid Dist. Metac. V.	11-3	12-2	13-9	15-0
13-7	14-3	15-6	15-11	Sesamoid Thumb Interphal.	11-3	12-2	14-2	15-3

TABLE VI. RANGE IN TIME OF APPEARANCE OF OSSEOUS CENTERS IN THE HAND AND FOOT
(Ages given in years and months except as indicated)

Boys: Range of middle 80 per cent (from)	Boys: 50 per cent (from)	Boys: 50 per cent (to)	Boys: Range of middle 80 per cent (to)	HAND		Girls: Range of middle 80 per cent (from)	Girls: 50 per cent (from)	Girls: 50 per cent (to)	Girls: Range of middle 80 per cent (to)
1-8	2-1	3-2	3-11	Metacarpal	1	1-1	1-3	1-10	2-1
1-1	1-3	1-11	2-5		2	0-9	0-11	1-4	1-6
1-1	1-5	2-0	2-9		3	0-10	0-11	1-4	1-9
1-3	1-7	2-6	2-11		4	0-11	1-1	1-5	1-10
1-5	1-8	2-9	3-4		5	1-1	1-2	1-8	1-11
1-11	2-3	3-5	3-11	Prox. Phalanx	1	1-2	1-4	1-11	2-4
0-11	1-1	1-8	1-11		2	0-7	0-9	1-0	1-4
0-10	1-1	1-6	2-0		3	0-7	0-8	1-0	1-3
1-0	1-2	1-9	2-0		4	0-7	0-9	1-0	1-4
1-3	1-6	2-4	2-10		5	0-10	1-0	1-5	1-8
1-5	1-8	2-7	3-0	Midd. Phalanx	2	0-10	1-0	1-7	1-11
1-3	1-7	2-6	2-11		3	0-9	0-11	1-5	1-10
1-3	1-7	2-6	2-11		4	0-10	0-11	1-6	1-9
2-2	2-7	4-3	5-0		5	1-2	1-5	2-3	2-8
1-0	1-2	1-11	2-7	Dist. Phalanx	1	0-7	0-9	1-3	1-6
2-3	2-8	3-10	4-6		2	1-3	1-7	2-5	2-10
1-8	2-0	2-10	3-4		3	0-11	1-2	1-10	2-1
1-8	2-1	2-11	3-5		4	1-0	1-2	1-10	2-3
2-3	2-8	3-10	4-7		5	1-3	1-7	2-5	2-10

TABLE VIII. RANGE OF OSSEOUS DEVELOPMENT OF GIRLS BY AGE FROM BIRTH TO 14 YEARS

AGE	RETARDED	BELOW AVERAGE	LOW AVERAGE	HIGH AVERAGE	ABOVE AVERAGE	ACCELERATED	RATING
Birth	Calcaneus Talus Dist. Femur	----------	Prox. Tibia	Cuboid	Hd. Humerus	Capitate Hamate Coracoid (Scap.)	
3 mo.	Prox. Tibia Cuboid Hd. Humerus	----------	Capitate Hamate Coracoid (Scap.) 3rd Cuneiform	Capitellum Hd. Femur	Dist. Tibia	Gt. Tub. Hum.	
6 mo.	Capitate Humate Hd. Femur	Coracoid (Scap.) 3rd Cuneiform Dist. Tibia Capitellum	Ratio: Dist. Tibia 31	Gt. Tub. Hum.	Tarsus: Dist. 1	Dist. Radius Dist. Fibula Triquetrum 1st Cuneiform Carpus: Prox. 2 3 4 Dist. 1 Tarsus: Prox. 3 4	
9 mo.	Coracoid (Scap.) Capitellum Dist. Tibia	3rd Cuneiform Gt. Tub. Hum.	Tarsus: Dist. 1	Dist. Radius Dist. Fibula Carpus: Prox. 2 3 4 Dist. 1	Triquetrum 1st Cuneiform Metacarpal: 2 Tarsus: Prox. 3 4	2nd Cuneiform Navicular (T) Carpus: Prox. 5 Mid. 3 4 Metacarpal: 3 Tarsus: Prox. 2	
12 mo.	3rd Cuneiform Gt. Tub. Hum.	Dist. Fibula Carpus: Prox. 3 4 Tarsus: Dist. 1	Dist. Radius Carpus: Prox. 2 Dist. 1 Tarsus: Prox. 3 4	1st Cuneiform Carpus: Prox. 5 Mid. 2 3 4 Metacarpals: 2 3 Tarsus: Prox. 2	Triquetrum 2nd Cuneiform Navicular (T) Carpus: Dist. 3 4 Metacarpal: 4	Lunate Carpus: Prox. 1 Mid. 5 Metacarpals: 1 5 Tarsus: Prox. 1 5	
18 mo.	Dist. Fibula Dist. Radius Carpus: Prox. 2 3 4 Dist. 1 Metacarpal: 2 Tarsus: Prox. 3 4 Dist. 1	Carpus: Prox. 5 Mid. 3 4 Metacarpals: 3 4 Tarsus: Prox. 2	1st Cuneiform Carpus: Mid. 2 Dist. 3 4 Metacarpals: 1 5 Tarsus: Prox. 1	Triquetrum 2nd Cuneiform Carpus: Prox. 1 Mid. 5 Tarsus: Prox. 5 Metatarsal: 1	Navicular (T) Carpus: Dist. 2 5 Metatarsal: 2	Lunate Gt. Tr. Femur Patella Prox. Fibula Tarsus: Dist. 3 4 Metatarsal: 3	

TABLE VIII—CONT'D

AGE	RETARDED	BELOW AVERAGE	LOW AVERAGE	HIGH AVERAGE	ABOVE AVERAGE	ACCELERATED	RATING
2 yr.	Carpus: Prox. 5 Mid. 2 3 4 Metacarpals: 3 4 5 Tarsus: Prox. 1 2 Metatarsal: 1	1st Cuneiform Carpus: Prox. 1 Dist. 3 4 Metacarpal Tarsus: Prox. 5	2nd Cuneiform Navicular (T) Carpus: Mid. 5 Dist. 2 5 Metatarsal: 2	Triquetrum	Lunate Gt. Tr. Femur Patella Prox. Fibula Tarsus: Dist. 3 4 Metatarsal: 3	Med. Epi. Hum. Gt. Mult. Tarsus: Dist. 2 **Metatarsal: 4**	
3 yr.	1st Cuneiform 2nd Cuneiform Carpus: Prox. 1 Mid. 5 Dist. 2 3 4 5 Metacarpal: 1 Tarsus: Prox. 5 Metatarsal: 2	Triquetrum Navicular (T) Gt. Tr. Femur Patella Tarsus: Dist. 4 Metatarsal: 3	Lunate Prox. Fibula Tarsus: Dist. 2 3 Metatarsal: 4	Metatarsal: 5	Med. Epi. Hum. Prox. Radius Gt. Mult.	Navicular (C) Less. Mult.	
4 yr.	Triquetrum Navicular (T) Gt. Tr. Femur Patella Tarsus: Dist. 3 4 Metatarsals: 3 4	Lunate Prox. Fibula Tarsus: Dist. 2 Metatarsal: 5	Med. Epi. Hum.	Prox. Radius Navicular (C) Gt. Mult. Less. Mult.	Ratio: Dist. Radius 86	Acc. Calc. 1 Dist. Ulna	
5 yr.	Lunate Prox. Fibula Tarsus: Dist. 2 Metatarsal: 5	Med. Epi. Hum. Less. Mult.	Prox. Radius Navicular (C) Gt. Mult.	Acc. Calc. 1	Dist. Ulna	Ratio: Dist. Ulna 55	
6 yr.	Med. Epi. Hum. Navicular (C) Gt. Mult. Less. Mult.	Prox. Radius Acc. Calc. 1	Dist. Ulna	Ratios: Prox. Rad. 62 Dist. Ulna 27	Ratio: Dist. Ulna 50	Trochlea Hum. Prox. Ulna 1 Pisiform	
7 yr.	Prox. Radius Acc. Calc. 1	Dist. Ulna Ratio: Prox. Rad. 44	Ratios: Prox. Rad. 62 Dist. Ulna 37	Ratio: Dist. Ulna 61	Prox. Ulna Trochlea Hum. Pisiform	Epiph. Talus	
8 yr.	Dist. Ulna	Ratios: Prox. Rad. 66 Dist. Ulna 51	----------	Prox. Ulna 1 Epiph. Talus Pisiform Trochlea Hum.	----------	Lat. Epi. Hum. Epiph. Base Metat. V Fusion: Talus	

9 yr.	----------	Epiph. Talus Prox. Ulna 1	Pisiform Trochlea Hum.	Lat. Epi. Hum. Fusion: Talus	Epiph. Base. Metat. V	Prox. Ulna 2 Acc. Calc. 2 Sesamoid: Metac. I, 1	
10 yr.	Prox. Ulna 1 Epiph. Talus	Pisiform Trochlea Hum. Fusion: Talus	Lat. Epi. Hum.	Epiph. Base. Metat. V Prox. Ulna 2 Sesamoid: Metac. I, 1	Acc. Calc. 2	Sesamoid: Metac. I, 2 Fusion: Base Metat. V	
11 yr.	Pisiform Trochlea Hum. Lat. Epi. Hum. Fusion: Talus	----------	Epiph. Base Metat. V Sesamoid: Metac. I, 1	Prox. Ulna 2 Acc. Calc. 2 Sesamoid: Metac. 1, 2	Fusions: Base Metat. V Trochlea Hum.	Sesamoids: Metac. V Thumb Dist. Fusion: Lat. Epi. Hum.	
12 yr.	Epiph. Base Metat. V Sesamoid: Metat. I, 1	Prox. Ulna 2	Acc. Calc. 2 Sesamoid: Metac. I, 2 Fusions: Base Metat. V	Fusion: Trochlea Hum. Lat. Epi. Hum.	Sesamoids: Metac. V Thumb Dist.	Fusions: Prox. Ulna 1 2 Prox. Radius Med. Epi. Hum. Dist. Tibia Acc. Calc. 1 2	
13 yr.	Prox. Ulna 2 Sesamoid: Metac. I, 2	Acc. Calc. 2 Fusions: Trochlea Hum. Base Metat. V	Fusions: Lat. Epi. Hum. Sesamoid: Metac. V	Fusions: Prox. Ulna 1 2 Prox. Radius Med. Epi. Hum. Sesamoid: Thumb Dist.	Fusions: Dist. Tibia Acc. Calc. 1 2	----------	
14 yr.	Fusions: Base Metat. V Lat. Epi. Hum.	Sesamoid: Metac. V	Sesamoid: Thumb Dist. Fusions: Prox. Ulna 1 2 Prox. Radius Med. Epi. Hum.	Fusions: Acc. Calc. 1 2 Dist. Tibia	----------	Fusion: Dist. Ulna	

A child may be expected to have all the epiphyses noted in the "Retarded" classification, up to and including her age.

Underline all the epiphyses which are present in the columns opposite her age.

For proper classification at least one-half of the centers in a particular grouping should be present.

Disregard the absence of a center in a low category when the majority of the centers are present in a higher grouping.

If there is no view of a particular center, cross it out in such a way that it does not influence the rating by appearing to be absent.

Ratio indicates the percentage relationship between the maximal transverse diameter of the epiphysis and the maximal diameter of the adjacent diaphysis.

The tibial ratios were obtained from lateral views, ratios of the radius and ulna from A.P. views.

Table IX. Range of Osseous Development of Boys by Age From Birth to 14 Years

AGE	RETARDED	BELOW AVERAGE	LOW AVERAGE	HIGH AVERAGE	ABOVE AVERAGE	ACCELERATED	RATING
Birth	Calcceaneus Talus Dist. Femur	--------	Prox. Tibia	----------	Cuboid Hd. Humerus Coracoid (Scap.)	Capitate Hamate	
3 mo.	Prox. Tibia	Cuboid Hd. Humerus	----------	Capitate Hamate Coracoid (Scap.) 3rd Cuneiform	Capitellum Hd. Femur Dist. Tibia	----------	
6 mo.	Cuboid Hd. Humerus Capitate	Hamate Hd. Femur Dist. Tibia	Coracoid (Scap.) Capitellum 3rd Cuneiform	Ratio: Dist. Tibia 41	Gt. Tub. Hum.	Dist. Radius Dist. Fibula Triquetrum	
9 mo.	Hamate Hd. Femur Dist. Tibia	Coracoid (Scap.) Capitellum 3rd Cuneiform	Ratio: Dist. Tibia 46	Gt. Tub. Hum.	Dist. Radius Dist. Fibula Triquetrum	1st Cuneiform 2nd Cuneiform Carpus: Prox. 2 3 4 Dist. 1 Tarsus: Dist. 1	
12 mo.	Coracoid (Scap.)	3rd Cuneiform Capitellum	Gt. Tub. Hum.	Dist. Radius Dist. Fibula	Triquetrum 1st Cuneiform Carpus: Prox. 2 3 4 Dist. 1 Tarsus: Dist. 1	2nd Cuneiform Navicular (T) Carpus: Mid. 3 Metacarpals: 2 3 Tarsus: Prox. 2 3 4	
18 mo.	3rd Cuneiform Capitellum	Gt. Tub. Hum. Dist. Radium Dist. Fibula Carpus: Prox. 3 Tarsus: Dist. 1	Carpus: Prox. 2 4	Triquetrum 1st Cuneiform Carpus: Dist. 1 Metacarpals: 2 3 Tarsus: Prox. 2 3 4	2nd Cuneiform Carpus: Prox. 5 Mid. 2 3 4 Metacarpals: 4 5	Navicular (T) Lunate Carpus: Dist. 3 4 Metacarpal: 1 Metatarsal: 1	
2 yr.	Dist. Radius Dist. Fibula Carpus: Prox. 2 3 Tarsus: Dist. 1	Gt. Tub. Hum. Carpus: Prox. 4 Dist. 1 Metacarpal: 2 Tarsus: Prox. 3	Carpus: Prox. 5 Mid. 2 3 4 Metacarpals: 3 4 Tarsus: Prox. 2 4	Triquetrum 1st Cuneiform 2nd Cuneiform Metacarpal: 5 Metatarsal: 1	Navicular (T) Lunate Carpus: Prox. 1 Dist. 3 4 Metacarpal: 1 Tarsus: Prox. 1 5	Prox. Fibula Carpus: Mid. 5 Dist. 2 5 Metatarsal: 2	

3 yr.	Gt. Tub. Hum. Carpus: Prox. 4 5 Mid. 2 3 4 Dist. 1 Metacarpals: 2 3 4 Tarsus: Prox. 2 3 4	1st Cuneiform Carpus: Dist. 3 4 Metacarpal: 5 Tarsus: Prox. 1 5 Metatarsal: 1	Triquetrum 2nd Cuneiform Navicular (T) Carpus: Prox. 1 Metacarpal: 1 Metatarsal: 2	Lunate Carpus: Mid. 5 Dist. 2 5	Gt. Tr. Femur Patella Prox. Fibula Metatarsal: 3	Tarsus: Dist. 2 3 4 Metatarsal: 4	
4 yr.	1st Cuneiform 2nd Cuneiform Carpus: Prox. 1 Dist. 3 4 Metacarpals: 1 5 Tarsus: Prox. 1 5 Metatarsal: 1	Triquetrum Navicular (T) Carpus: Dist. 2 5 Metatarsal: 2	Lunate Gt. Tr. Femur Prox. Fibula Carpus: Mid. 5 Metatarsals: 3 4	Patella Tarsus: Dist. 3 4 Metatarsal: 5	Prox. Radius Tarsus: Dist. 2	Med. Epi. Hum. Navicular (C) Gt. Mult. Less. Mult.	
5 yr.	Triquetrum Navicular (T) Gt. Tr. Femur Carpus: Dist. 2 5 Metatarsals: 2 3	Patella Prox. Fibula Carpus: Mid. 5 Metatarsal: 4	Lunate Tarsus: Dist. 2 3 4 Metatarsal: 5	Prox. Radius Less. Mult.	Med. Epi. Hum. Navicular (C) Gt. Mult.	Ratio: Prox. Rad. 54	
6 yr.	Lunate Patella Prox. Fibula Carpus: Mid. 5 Tarsus: Dist. 3 4 Metatarsals: 4 5	Tarsus: Dist. 2	Prox. Radius	Med. Epi. Hum. Navicular (C) Gt. Mult. Less. Mult.	Dist. Ulna Ratio: Prox. Rad. 62	Acc. Calc. 1	
7 yr.	Tarsus: Dist. 2	Prox. Radius Navicular (C)	Med. Epi. Hum. Gt. Mult. Less. Mult.	Dist. Ulna Ratio: Prox. Rad. 55	Acc. Calc. 1 Ratio: Prox. Rad. 71	Prox. Ulna 1	
8 yr.	Prox. Radius Navicular (C)	Med. Epi. Hum. Gt. Mult. Less. Mult.	Dist. Ulna Acc. Calc. 1 Ratio: Dist. Ulna 31	Ratios: Prox. Rad. 73 Dist. Ulna 57	Ratio: Dist. Ulna 76	Epiph. Talus Trochlea Hum. Prox. Ulna (1) Pisiform	

TABLE IX.—Cont'd

AGE	RETARDED	BELOW AVERAGE	LOW AVERAGE	HIGH AVERAGE	ABOVE AVERAGE	ACCELERATED	RATING
9 yr.	Med. Epi. Hum. Gt. Mult. Less. Mult. Dist. Ulna	Acc. Calc. 1 Ratio: Dist. Ulna 36	Ratios: Dist. Ulna 61 Prox. Rad. 73	Trochlea Hum. Ratio: Dist. Ulna 76	Epiph. Talus Prox. Ulna (1) Pisiform	--------	
10 yr.	Acc. Calc. 1	Ratios: Prox. Rad. 77 Dist. Ulna 52	Trochlea Hum.	Epiph. Talus Prox. Ulna (1)	Pisiform Fusion: Talus	Lat. Epi. Hum. Acc. Calc. 2 Sesamoid: Metac. I (1) Epiph. Base Metat. V	
11 yr.	Epiph. Talus	Trochlea Hum. Prox. Ulna (1)	----------	Pisiform Lat. Epi. Hum. Fusion: Talus	Acc. Calc. 2 Epiph. Base Metat. V	Prox. Ulna (2) Sesamoid: Metac. I (1)	
12 yr.	Trochlea Hum. Prox. Ulna (1)	Pisiform	Lat. Epi. Hum. Fusion: Talus	Epiph. Base Metat. V Sesamoid: Metac. I (1) Acc. Calc. 2	Prox. Ulna (2) Sesamoid: Metac. I (2)	Fusion: Base Metat. V	
13 yr.	Pisiform Lat. Epi. Hum.	Fusion: Talus	Epiph. Base Metat. V Sesamoid: Metac. I (1) Acc. Calc. 2 Prox. Ulna 2	----------	Sesamoid: Metac. I (2) Fusion: Base Metat. V	Sesamoids: Metac. V Thumb Dist. Fusions: Trochlea Hum. Lat. Epi. Hum.	
14 yr.	Epiph. Base Metat. V Fusion: Talus	Sesamoid: Metac. I (1) Acc. Calc. 2 Prox. Ulna (2)	Sesamoid: Metac. I (2)	Fusions: Base Metat. V Trochlea Hum. Sesamoid: Metac. V	Sesamoid: Thumb Dist. Fusion: Lat. Epi. Hum.	Fusions: Acc. Calc. 1, 2 Dist. Tibia Prox. Ulna 1, 2 Prox. Radius Med. Epi. Hum.	

A child may be expected to have all the epiphyses noted in the "Retarded" classification, up to and including his age.

Underline all the epiphyses which are present in the columns opposite his age.

For proper classification at least one-half of the centers in a particular grouping should be present.

Disregard the absence of a center in a low category when the majority of the centers are present in a higher grouping.

If there is no view of a particular center, cross it out in such a way that it does not influence the rating by appearing to be absent.

Ratio indicates the percentage relationship between the maximal transverse diameter of the epiphysis and the maximal diameter of the adjacent diaphysis.

The tibial ratios were obtained from lateral views, ratios of the radius and ulna from A.P. views.

that this center does not influence the rating by appearing to be absent. The vertical category in which half or more of the expected centers are present is the one which represents the child's osseous development. The absence of a center in a low category should be ignored if the majority of the centers are present in the next higher grouping. Likewise, the presence of a center or centers in a category much above the rating should be disregarded.

A chart similar to Tables VIII and IX is kept for each child. At each examination the chart is filled in opposite the appropriate age. This offers a simple method for rapid estimation of a child's osseous development. The same chart used at repeated examinations has the advantage of showing whether a child is maintaining his previous rate of development, falling behind, or is accelerating.

An analysis of the osseous ratings over long periods of time shows that the children in this study maintained a comparatively constant rate of development. Eighty-seven children had osseous ratings at birth, 2, 4, 6, 8, and 10 years. Thirty-two of these also were rated at 12 years and forty-three of them had a rating at 14 years.

J. A. S.

The type occurring most frequently was the single bilateral (5 per cent) type, with the multiple bilateral type being second (1.49 per cent). Single and multiple unilateral types occurred quite infrequently. Bilateral tori (single and multiple) represent approximately 80 per cent of all mandibular tori observed.

Of the 2,478 subjects screened, 75 (3.03 per cent) possessed both palatine and mandibular tori. The 95 per cent confidence interval of ± 0.67 indicates that there is no correlation between the frequency of occurrence of palatine and mandibular tori.

Torus palatinus and torus mandibularis have been observed in both sexes and in all races examined. However, the frequency of occurrence varies and the age groups examined influence the numbers of tori observed.

The torus palatinus is much more common than the torus mandibularis. The high incidence of torus palatinus (20.9 per cent) in a group of 2,478 individuals reporting for dental treatment is in agreement with studies on similar groups but not with observations in different types of individuals. American Indians (60 per cent), Japanese (43.7 per cent), and Eskimos (60 per cent) showing much different occurrence than an American or Peruvian (30.5 per cent) population suggests a genetic influence. The marked sex difference of 2 to 1 ratio in favor of females in the American and Caucasian groups (O.S.U., Lachmann and Miller and Roth) and a reversal to 1.5 to 1 favoring females in the Peruvian groups does not suggest a sex linkage. It appears that the torus palatinus develops primarily in the first thirty years of life. Miller and Roth's data indicate that it may continue to increase in size during later decades.

The torus mandibularis observed in 192 (7.75 per cent) of 2,478 individuals cannot be classified as rare. It did not appear to vary with sex or race among a Middle Western United States population group. It was found more frequently in American and African Negroes (11.3 per cent), American Indians (13 per cent), Aleuts (35 per cent), and Alaskan Eskimo (41.8 per cent), and in some of the groups some sex difference was found with the males having a somewhat higher incidence than females. Moorrees' observation of marked differences in Eastern (61 per cent) and Western (26 per cent) Aleuts, and comparison with findings of other studies, suggests a genetic influence.

The infrequent observation of coexisting tori of the palate and mandible (3.03 per cent of 2,478 individuals) does not support the view that tori represent part of a general tendency to produce exostoses.

Palatine tori occurred in 20.9 per cent of the total group.

Sex distribution for torus palatinus revealed a significant difference in percentage (males, 14.7 per cent, females 26.7 per cent), with approximately a 2 to 1 ratio favoring the female.

Race distribution of palatine tori shows an insignificant difference between white and non-white (95 per cent Negro) elements in this study, although comparison with other studies of racial groups is suggestive.

Age distribution of palatine tori suggests a "leveling off" phenomenon after the third decade of life, with the subsequent decades showing no significant difference in percentage of occurrence. This would tend to indicate that palatine tori usually have their onset by approximately 30 years of age.

Flat tori (49 per cent) and spindle-shaped tori (35 per cent) occurred most frequently as opposed to lobular (7.9 per cent) and nodular (6.5 per cent) types.

Mandibular tori were observed in 7.75 per cent of the total group.

Sex distribution and race distribution revealed no significant difference in this group.

Age distribution shows a "leveling off" phenomenon manifests itself after the third decade of life group, with subsequent decades showing no significant difference in percentage of occurrence. This indicates that mandibular tori usually have their onset by approximately 30 years of age.

Bilateral mandibular tori (single bilateral, 63 per cent; multiple bilateral, 17 per cent) collectively occurred more frequently than unilateral tori (single unilateral, 14 per cent, multiple unilateral, 0.12 per cent).

Seventy-five subjects of the total sample (3.03 per cent) possessed both palatine and mandibular tori.

The data for both palatine and mandibular tori, when compared with that of other investigators, show that palatine and mandibular tori occur with great frequency in the Mongoloid race as compared to the Caucasian and Negroid groups.

News and Notes

American Association of Orthodontists

About the time this May JOURNAL comes off the press, the American Association of Orthodontists should be in session at the Palmer House in Chicago. The dates of the meeting are May 16 through May 20, and at this time it appears the A. A. O. will enjoy one of the best attended meetings ever held in its entire history.

Medical Library Association

The Medical Library Association will hold its Fifty-third Annual Meeting, June 15 through 18, 1954, in Washington, D. C. The headquarters will be the Hotel Statler, and the official host will be the Armed Forces Medical Library.

Further information can be obtained from Lt. Col. Frank B. Rogers, Armed Forces Medical Library, 7th St. and Independence Ave., S. W., Washington 25, D. C.

Northwestern University Dental School

On June 21, 22, and 23, 1954, the Graduate Department of Orthodontics of Northwestern University Dental School will present an Advanced Course on Cephalometric Radiography. Emphasis will be placed on (1) serial cephalometrics, viz., before, after, and some years subsequent to orthodontic therapy, and (2) functional cephalometrics, viz., analysis of mandibular displacement, vertical dimension problems, and temporomandibular joint dysfunction. A manual of serial and functional tracings and duplications of cephalometric radiographs will be issued to each student.

For information please contact the Director of Graduate and Postgraduate Courses, Northwestern University Dental School, 311 East Chicago Ave., Chicago, Ill.

University of North Carolina

The University of North Carolina, School of Dentistry, announces its graduate program in orthodontics, oral surgery, and pedodontics, leading to a Master's Degree or a certificate. The graduate programs in orthodontics and pedodontics require fifteen months in residence, while twenty-four months are required in oral surgery.

For further information please write the Dean, School of Dentistry, University of North Carolina, Chapel Hill, N. C.

Notes of Interest

Claude R. Wood, D.D.S., announces the removal of his offices to the Lake Avenue Dental Bldg., Lake at Melrose, Knoxville, Tenn., practice limited to orthodontics.

OFFICERS OF ORTHODONTIC SOCIETIES

The American Journal of Orthodontics is the official publication of the American Association of Orthodontists and the following component societies. The editorial board of the American Journal of Orthodontics is composed of a representative of each one of the component societies of the American Association of Orthodontists.